PIPELINE HAZARD MONITORING AND REPORTING IN UNDERWATER WIRELESS SENSOR NETWORKS

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requirements for the award of the degree of
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Department of Computer Sciences
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DECLARATION

I declare that this thesis entitled "*Pipeline Hazard Monitoring and Reporting in Linear Wireless Sensor Networks*" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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The thesis is dedicated to my parents and teachers who have loved me unconditionally and who have set good examples for me throughout my educational career. The individuals who have taught me to work hard for the things that I aspire to achieve.

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ABSTRACT

Linear Wireless Sensor Network (LWSN) is a sensor deployment technique in which sensors are deployed or placed in a structure which is in-line or in a linear form known as linear infrastructure. Pipeline hazards like damage or leakage are supervised by the usage of LWSN, and reported to the control center or base station. Further suitable actions are required to minimize or sort out the reported issue, as well as to save the underwater environment, habitat and economy. The main issue with the Autonomous Underwater Vehicle (AUV) is that it traverses to every sensing node for the collection of data which causes energy loss. This work gives a variable speed-based and fixed speed-based collection of data from sensing devices in which nodes are placed, it includes relay nodes as well as data distribution nodes. It reduces the communication cost in the data collection process for the variable speed and fixed speed AUV scenario. AUV gathers data from responsible data distribution nodes, which receive data from low power devices. Furthermore, in this work the simulations are performed in NS2 for validation. The proposed scheme provides encouraging results in terms of delay, communication cost, energy consumption, buffer size, and delivery ratio when compared with different algorithms.

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LIST OF ABBREVIATIONS

AUV	-	Autonomous Underwater Vehicle
BSN	-	Basic Sensor Node
DDN	-	Data Dissemination Node
DRN	-	Data Relay Node
MI	-	Magnetic Induction
NCC	-	Network Control Centre
SN	-	Sink node
UAV	-	Unmanned Aerial Vehicle
UW	-	Under Water
UAV	-	Unmanned Aerial Vehicle
WPN	-	Water Pipeline Monitoring
WSN	-	Wireless Sensor Node
LWSN	-	Linear Wireless Sensor Network

LIST OF SYMBOLS

Bwd	-	Backward
Cal	-	Calculated
Dir	-	Direction
Dist / D	-	Distance
Dist-calc	-	Distance calculated
Nx	-	Next
Pr	-	Previous
TDDN	-	Total DDN
s	-	AUV speed
Dr/dr	-	Delivery ratio
d	-	Delay
Fwd	-	Forward

CHAPTER 1

INTRODUCTION

1.1 Overview

Linear wireless sensor network (LWSN) is a special kind of WSN, in which nodes are placed or deployed in a linear structure. Far from the traditional applications of WSN, like monitoring of railway tracks, gas and oil pipelines, placement of sensor nodes in a linear structure is required due to their linear infrastructure. The elements of LWSN include: sensor nodes, forwarding nodes and distribution nodes [1]. At an extreme low level sensor nodes are placed, purpose of sensing nodes is sensing and collecting data. Further forwarding data to the relay nodes that are higher than the sensor nodes. Afterwards relay nodes send data to data dissemination nodes that are at a higher level than the relay nodes. Further Autonomous Underwater Vehicles (AUV) collect data from the data dissemination nodes and forward to the surface sink node, in the end data is sent to the server.

1.2 Research Motivation

LWSN is an emerging area, and also sensors are used in a wide range of applications like health care, sports etc. Feel motivated and interested in this area to work. Detection of leakages and damage in underwater pipeline is a challenge, although lot of work is done in that area but still improvement is needed. For example energy- efficiency, life of sensors, minimum response time (when leak or damage is detected). It motivated me to resolve these issues and propose a reliable scheme for pipeline detection in an efficient manner.

1.3 Techniques for Pipeline Monitoring:

There are different methods for pipeline monitoring. First method completely depends on human effort, in which maintenance workers are used for the inspection periodically. But this method is not suitable for real-time monitoring, it could be highly expensive and may not primarily reduce certain threats. To resolve the issue of monitoring in a real-time, wired sensors network are used. In this technique wired medium such as cooper wires or fiber optics is used to connect the sensor's network. But in this case deployment is costly and if damage is done, it effects the entire monitoring system. It's easy to disable the wired network just by cutting the wires. Finally, it's hard to find a liability and then repairing it, specifically in underground pipelines [2, 3]. Further, by using Wireless Sensor Networks (WSNs) pipelines can be continuously monitored. So it reduces the loss of materials like natural gas, and even a small leakage of gas may cause a disaster. Moreover, in the case of wireless medium, establishment of a network is easy because no wires are used for communication. So, maintenance cost is reduced in wireless networks [4, 5]. In WSN monitoring system, monitoring points are normally picked across the pipeline. Also, sensors are deployed in a linear structure in outside, as well as inside of the pipeline for the checking of pipelines' health and also gather the particular data that is related to the transferring material flowing by the pipeline. Sensors communicate through radio waves that forward the gathered data to the control (base) station [6]. In [3], MISE-PIPE is a surveillance system for underground pipelines system uses WSN. The purpose of MISE-PIPE is to discover and detect damage or leakage in underground pipelines through using internal sensors, external sensors, pressure sensors, property sensors, acoustic and soil sensors. It provides accurate real-time leakage findings and localizations [3]. Also tracking of a pipeline by using LWSN. On the pipeline sensor nodes are attached, sensor nodes sense and collect data, then forward it to the sink nodes. Further sink nodes forward data to the control center.

1.4 Applications of UWSNs

In this section some applications of underwater wireless sensor networks (UWSNs) are discussed. There are lot of applications of UWSNs, but some are discussed below. These are natural hazard detection, military operations, and underwater pipeline monitoring.

1) Natural Hazard Detection

Haque et al. proposes a less powerful sensor network for underwater which makes a system to be able to create early warning creation of natural disasters such as tsunami, earthquakes, floods, hurricanes. Data is gathered by the sensors at the sea bed. UWSN gather and forward required data from the surface of sea to the floating surface station. Surface station forwards it to the satellite that eventually ties the data down to the data gathering center [66]. Gathered data is analyzed at this center and the warning is created if required.

2) Military Operations

UWSN is utilized for the operation of Mine Countermeasure (MCM). Autonomous underwater vehicle (AUV) combined with the side sonar for the identifying and mapping the area which is target. Various AUVs may be used as well as they exchange data with each other. Gateway nodes are placed at the surface of water and equipped with transceivers. These nodes allow the AUVs to monitor from an operating system which is at a distance [66].

3) Underwater Pipeline Monitoring

UWSN is utilized in monitoring system for the underwater pipeline. Static sensors are attached with the pipeline. Their purpose is to gather data and forward it to the dynamic nodes which are floating. After which floating nodes send data to sink node, data reaches at control center by using RF communication [66].

1.5 Problem Statement

This work addresses the issue of inefficient utilization of energy, emergency event handling, and more number of messages while communication because of AUV visiting every node for gathering of data as shown in Figure 1.1. In the base scheme more number of messages are required for communication, because AUV visits every node for gathering of data. So, more energy is consumed. Also emergency events are not handled efficiently.

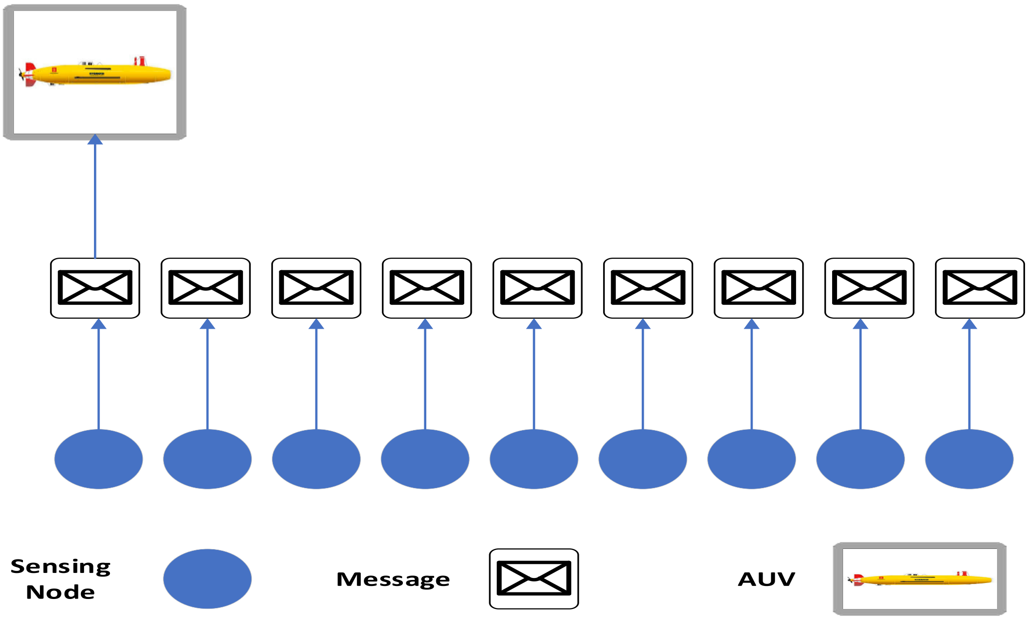

Figure 1.1: Problem scenario

1.6 Research Questions

Following research questions are identified to achieve the research objectives in this area of research.

1) What are the different mechanisms to detection of the pipeline?

2) What mechanisms to identify the pipeline leakage?

3) What are the mechanism to locate the target region?

4) What are the mechanism to efficiently collect the data and reporting to server?

1.7 Aim of the Research

Aim of this work is to create a scheme which is energy efficient, utilizes smaller number of messages, and handles emergency scenario in efficient manner. Hierarchical model for nodes deployment is used in this scheme.

1.8 Research Objectives

In this work, following are the main research objectives that are main concerns to achieve for this topic of research.

1) Pipeline detection efficiently.

2) Detection of leakage timely and efficiently.

3) Identify the pipeline leakage and timely reporting from target area.

1.9 Thesis Organization

The rest of thesis is organized as follows: Chapter 2 is about related literature studies, Chapter 3 is about methodology, and Chapter 4 is about design and development of given scheme, then Chapter 5 is about evaluation of simulation, finally Chapter 6 gives conclusion as well as contribution and future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

In this section schemes are discussed that are related to pipeline surveillance and collection of data from sensors. Also, pros and cons of the previous techniques are discussed. The literature is divided in six categories that are heterogeneous based schemes, swarm intelligence-based schemes, and vehicle-based schemes, Internet of Things (IoT) based schemes, hybrid-based schemes, and miscellaneous based schemes. Moreover put related schemes under specific category. Those schemes that follow hierarchical model or use nodes with different level /power in the network come under heterogeneous based schemes. The schemes who use AUV for the purpose of data collection come under vehicle-based schemes. Moreover under the heading of swarm intelligence-based schemes, swarm-based techniques are discussed such as Ant Colony Optimization (ACO). Schemes which uses IoT are placed under the IOT based schemes. Finally remaining are put under the heading of miscellaneous based schemes.

2.2 Schemes of Literature

As mentioned in the overview, literature is categorized into six categories, in this section those schemes are put under a specific category.

2.2.1 Heterogeneous Data Collection Schemes

Jawhar et al. discussed that the ad-hoc and sensor networks is a speedily growing and for researchers it is a new research area due low-cost sensors. Those sensors have high capability of storage, networking, communication and processing speed [2]. Those sensors are used in variety of areas like forestry, military, livestock, robotics, and healthcare. This paper highlights the challenges and issues of this very successful and modern technology to track and secure the sensitive and necessary infrastructure of water, gas, and oil and other pipelines of important resources. This paper gives a model for architecture which are used for the purpose of the monitoring and controlling. That model consists of an overview of networking and routing protocols which are used to provide the necessary communication. This paper also gives discussion and guidelines on network reliability, and also the various protocol's usage and WSN's technology.

In [5], some uses provides by WSNs are discussed like military, industrial, farming, healthcare and robotics. This article focuses on some areas like security, protection, water, oil and gas pipelines using WSNs. ROLS: routing protocol for LWSNs is presented with a new scheme of hierarchical addressing. ROLS: a routing protocol for linear structure WSNs is presented with a new scheme of hierarchical addressing for this kind of networking environment. Networking and related protocol's framework are design to avail advantage of network's linear design to minimize the continuance the placement cost, reduce energy need, enhance efficiency and reliability in communication. Moreover, simulation shown of proposed model.

Abbas at el. presented nodes placement or deployment algorithm whose nature is dynamic and scalable. The provided deployment model which allows coverage of pipelines of different sizes [18]. The given topology model is nature wise distributed, that divides the length of pipeline into segments. Addition of nodes or removal of one or more nodes from existing is allowed, that's why it is scalable in nature. Algorithm defines a mathematical model, also node's position calculate corresponding to the length of pipeline. The key benefit of this technique it is helpful to reduce the delay at a minimum level for the purpose of finding the problems such as damage or leakage in the underwater pipeline. This given algorithm provides the support for finding the location of damaged or leaked area of the pipeline. Moreover, given model is helpful for reduction of computational overheads as mostly underwater acoustic communication be capable to support lowest data rate. Also, for long time monitoring of pipelines, this algorithm is useful. Furthermore, it is suitable for long pipeline's coverage; in which no restriction of network size.

Ali et al. in [19], are point-out some issues such as some factors are caused of the node's disconnection with other nodes, and LSNs are used to resolve that issue. For resolution of such issues, author gives an application that is used for the deployment of sensor network for the linear infrastructure such as pipeline of gas and oil; by using Simpli-Mote with algorithm for the resolution of issues such as leakage finding and route for messages that have high priority must be considering reliability. Presented system is useable for leakage detection, actuation, and sensing of parameters while considering low consumption of energy, less latencies and also high reliability of data. Given solution contains scheme to detect sensing events with the removal of noise on custom nodes, and routing information. Also make sure network must alive constantly while at real-time remote monitoring. Presented scheme is compare with Arduino-based Libelium, on the base of performance at a system level. Results gives a clear view that the presented leakage detection scheme is double in energy saving, reliable, and timely.

Abdelhafidh et al. in [23] author notice that the hydraulic failure may activate the Water catastrophic environmental hazards in Water Pipeline System (WPS). WSN are largely implement for the monitoring of structural health of pipeline and management the WPS. WSN's implementation is growing significantly. But there is a critical challenge in WSN that is energy consumption, improvement is required to ensure and secure seamless between sensor nodes. So many algorithms and techniques are available to resolve the issue of transmitted data quantity. In this scheme, combination of data aggregation and bio-inspired clustering algorithm for the improvement of WSN's lifetime.

Ugur et al. in [25], said that the research of military and commercial applications has attracted a great deal of interest from Underwater Acoustic Sensor Networks (UASNs). Generally, UASNs comprise of nodes, purpose of nodes is to gather data from underwater and transfer to base station. Also, many factors are included in underwater environment such as limited bandwidth, delay in propagation etc. There are two size of data packets that are transfer, which are small size and large size. Chances of packet loss is present when large size packets are transfer. But while transferring small size data packets very less chances of loss of packets than the large size. On the other hand, more frames are uses when small size packets are transfer. Energy consumption and life of network are dependent, it's mean if more energy is used then network's life time is reduced. For the resolution of that issue many methods are available, two methods are: transmission power control (TPC) and packet size optimization (PSO). In this scheme as a solution author suggest model (novel optimization) whose focus is on integer linear programming (ILP), combine the effect of TCP and PSO on network existence.

Abdelhafidh et al. in [46] said the Wireless Sensor Networks (WSN) are largely used to manage Water Pipeline system (WPS) monitoring structural health. Therefore, maintaining stable communication in a harsh environment of sensors is imperatively necessary in respect to facilitate continuous data gathering and processing. In this sense, to optimize the lifetime of network, author suggest and introduce an energy-efficient approach which makes a smooth interconnection of sensor nodes, and reliable transmission of data. An elimination of data redundancy strategy in put in after a step of clustering at every cluster head. An algorithm of data fusion based on Dempster-Shafer verification theory at a Base Station. This technique is given with objective of minimizing the networks' data size and thus saving energy consumption. The results in enhanced lifetime of WSN and WPS which are more improved. Pre-processing step is suggested and applied to after applying the K-ACO for WSNs' division to multiple clusters and to determine sensor nodes which is energy-efficient at every cluster, in respect to reduce the size of transmitted data and minimize energy utilization at head of cluster and also base station.

Albaseer et al. in [40], said the leakage in pipeline's network of gas, oil and water is a world issue; results of its serious effects on ecosystem. Many solutions for the monitoring network of pipeline either been suggested or are in service. However, these suggestions are time-consuming, costly, many are invasive, and causing continued activities to be disrupted. In sensing technologies advances make it possible to create an affordable non-intrusive solution. However, making a sensor networks which can track the pipeline continuously, find and report if anomaly, poses a range of challenges: energy saving, node deployment, throughput, data flow, etc. For deploying and grouping several sensors throughout/with the entire pipeline, this article proposes an extensible clustering algorithm. Each sensor's group adaptability selects a head of cluster, through utilizing this algorithm, that performs aggregation for incoming traffic from their members; then send to the head of next cluster and so on till it reaches on base station. Key contributions are: 1) Proposing an approach for node placement. 2) Perform large simulation experiments as well as prototype experiments. 3) Performing analysis for power usage of ongoing process. The results of the experiments which is based on prototype and simulation demonstrated substantial energy saving relative to contemporary methods. Explicitly end to end delay is not considered. Also, no related discussion or achievements in terms of that are given.

Nadeem et al. in [51] the routing protocols' design for the underwater wireless sensor networks (UWSNs) faces various challenges due to adverse nature of the aquatic environment, like optimal route choosing, propagation delay, etc. Although when routing plan's designing for UWSNs, efficiency of energy is assumed a key factor. Unnecessary data transference and communication over extended distances are expected to be managed for efficiently utilization of nodes' battery since data transference over extended distances causes the unequal waste of energy resulting in the formation of void holes. Due to existence of void hole, the node is not be able to send data to destination due to relay nodes' unavailability. In respect to prevent the formation of void holes, author gives a routing system that recognizes a void hole earlier to occurrence and choose an alternative path for delivery of data successfully. In respect to decrease the risk of data waste due to occurrence of void hole, author determines an appropriate amount of forwarders at every hop as back-up forwarder potential nodes. Furthermore, in respect to defeat the amount of redundant data, the transmission exchange spectrum is logically broken into sub-forwarding zones.

Simulations are performed to show results of claims. The results reveal that in respect of packet distribution ratio (PDR), overall energy tax, end to end delay and amount of useless packets, the given work is better as relative to base schemes (WDFAD-DRB and VHGOR).

2.2.2 Vehicle Based Schemes

Zahoor et al. in [20], said that in the past studies most deployment of nodes strategies do not assume heterogeneity also capacity of sensor nodes. Ineffective data delivery from the sensing nodes that are on underwater pipeline to the sink node which is on the water surface, previous strategies are a reason of that problem. Zahoor at el. presented a strategy named "Enhanced Underwater Linear Wireless Sensor Network Deployment (EULWSND)" for improving the robustness in a linear sensor underwater data collection. The given strategy EULWSND gives a deployment scheme for the sensors in monitoring of pipeline which is robust in nature. By using Aqua-Sim current node's deployment strategy also compared with some previous data collection schemes. Author categorize data collection schemes of literature in three categories that are Distributed Topology-Based, Chain-Based, and Autonomous Unmanned Vehicle-Based.

Also compared EULWSND with an existing scheme that is DARP-PM. Performance of this scheme is superior as comparison of the DARP-PM in respect of packet delivery ratio and lower overhead in communication. This provides better results in respect of more packet delivery 20.5%, and lower communication overhead 17.4%. Model is shown in Figure 2.1, in which flow of data gathering is shown firstly basic sensor nodes (BSN) gather data and sent to DRN. Further DRN deliver data to DDN, then DDN send data to AUV. Furthermore, AUV forward data to the sink node.

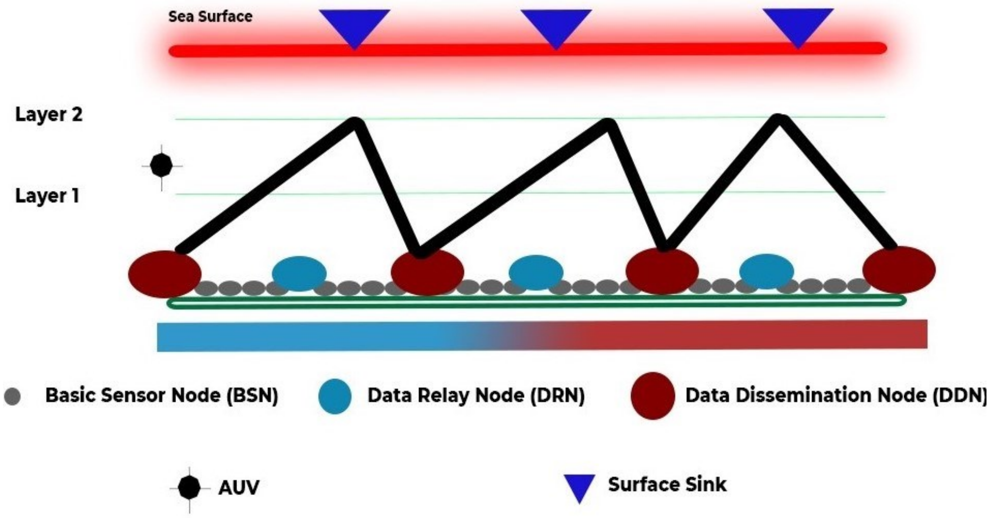

Figure 2.1: Heterogeneous Nodes model

Jawhar at el. in [21] focus on usage of LSNs to observe the underwater pipelines. A structure for the monitoring of underwater pipelines and safety, is given which use method that is AUV based LSN (ALSN). There are three categories of nodes used in ALSN architecture: sensor nodes (SNs), autonomous underwater vehicle (AUV), and surface sink node (or sink node). Author proposed a scenario in which autonomous underwater vehicles (AUVs) that move along the pipeline for the purpose of collecting data from sensor nodes (SNs), then sent data to the surface buoy node. Anyone from these nodes requires less, short range for the purpose of forwarding data to the AUV. Further AUV send data to the surface buoy. Usually, AUVs can visits the LSN segments of LSN with already defined capacities and velocities. But when emergency situation e.g., leakage, AUV can ignore some SNs for the purpose of fast delivery of emergency related data to the sink node. ALSN is largely useful in those applications in which increased end-to-end delay is acceptable and tolerable. ALSN also be useful in underwater applications, in underwater acoustic communication is typically used. But many limitations occur with acoustic communication that must be considered while making network architecture and protocols for this specific environment. Following challenges are: i) Band width is very less as compared to radio frequency. ii) Propagation delay is more than the radio frequency. iii) High rates, variable and irregular connectivity distinguish acoustic communication in underwater. As a result, more advanced error identification and resolution techniques will be used to indicate this notable constraint in the communication related protocols. iv) Latest signal processing techniques are needed to indicate the acoustic communication problems and challenges in underwater that are inborn. Duty of these signal processing upgrade the usage, power and the related energy requirements. There are two big techniques of sensor networks which are used for underwater pipeline monitoring: first one is wired sensor networks and second is WSN through multi-hop communication. In these two techniques the problem is cost of maintenance is high. Solution is proposed in current paper would increase the life time of node batteries as well as reduce the frequency; so that reduce the cost of overall network's maintenance. On the base of speed AUV have two kind of strategies, these are: AUV with constant speed (CSA) and AUV with variable speed (VSA).

In the case of CSA when AUV collects data from a node which is on one end and on the other end sink node is presented, maximum delay is noticed in it. In the case when AUV gather data from the node which is closest to the sink node. In this case delay noticed is 0. Also, in this scheme there are two further cases in VSA: these are AUV speed when it is in communication range (sc) and other is AUV speed when there is no communication (snc). Further, achievements are: given scheme is suitable in delay-tolerant applications. Also, this scheme does not use multi-hop communication, and gives reduced amount of energy consumption. Further in it reduced collisions, interference, and hidden terminal problems, those things are mostly available with multi-hop communication.

Flexibility in nodes placement is given in this scheme, and also problems of previous schemes are resolved. Furthermore, this can be enhanced by improving some parameters such as sensor nodes (SN) distance, density, and security etc. Flow of data is shown in Figure 2.2, where data gather by sensor nodes and sent to the AUV. The AUV passes to the surface sink that further transmits the data to the NCC.

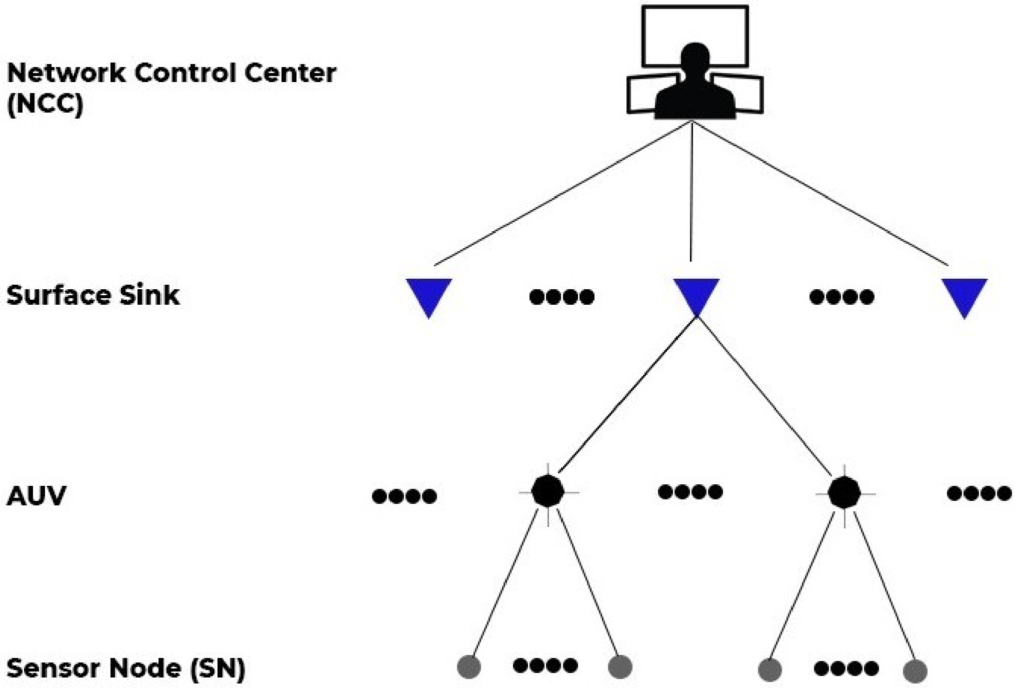

Figure 2.2: One-Level Nodes Deployment

Yuchang et al. in [27], said that monitoring of infrastructure is a valuable/main class of wireless sensor network (WSN) application. When WSN's are used it means human's participation is minimized. Also issue of wires are end by using WSN's, because in WSN for communication wireless medium is used. As well as task of monitoring of wires that are in a wired medium is eliminated. Main achievement of WSN is an early detection. As if early detection is done then as a result reduce the waste of economy, reduce the effects on environment is achieved. If a topology is designed for the structure which is linear like bridge, railway track this WNS's type is known as the linear wireless network (LWSN). In LWSN's hybrid structure, less nodes are required for the transferring of data to base nodes from the sensor nodes. Three node's types are used: 1) Sensor nodes. 2) Support nodes. 3) Station node. Some assumptions of author are following: 1) All nodes independently behave. 2) Support nodes have higher capability than sensor nodes, in terms of energy, storage, and transmission range as well as high availability. 3) The probability of failure of support nodes or sensor nodes are different. Failure's probability depends on geographical environment. For the monitoring of high-reliable infrastructure, LWSN which is hybrid in nature has made in which finite number of nodes for supporting purpose are used to transferring of data. In current scenario LWSN is assumed as a multi-state. In proposed paper, author proposed the multivalued decision diagram (MDD) based analytical approach to find the probability of hybrid LWSN's performance at a specific regarding to a number of the sensor nodes is capable to nodes of base station's reach. Especially, a procedure known as novel are suggested to make MDD models and the MDD's model's complexity is investigated. Main contribution of this paper is hybrid LWSN's analyzing and modeling at a multi-state, in which support nodes or sensor nodes follow arbitrary distribution of lifetime can be.

Tylor et al. said one of the demanding tasks is surveillance of environmental gasses which need monitoring for the long period also huge number of sensors are required. For monitoring of remote and those areas where access is difficult Unmanned Aerial Vehicles (UAVs) are suitable. AUV have a long range and variety in its size and shape, UAVs are a capability to carry the modules of sensors which is able to monitor the gas concentrations [28]. UAVs are able to carry the camera which is high resolution. This work expresses the UAV's flight testing and design that have an on-board camera and have a sensor for carbon dioxide gas is ability of sensing autonomous gas while detecting an assigned location of the room. The system for detecting navigates autonomously throughout the flight area by using the waypoint navigation system and hangs for ten seconds (10s) when target has identified visually taking samples of Air Quality (AQ) as you do. Several tests like bench, laboratory and field result show the UAV's capability to locate place of target in a room and quality of air is analyze by taking samples. The collected data while the flight is transmitted, real time, for the visualization as well as analysis back to Ground Control Station (GCS), where a web interface is provided with 3D maps of the target position and a gas concentration. Verified the ability by test cases of the integration of subsystem and the UAV's system. Algorithm of the image processing are used for the detection of target, based on method of cascade, the frame transmission speed has proven to be based on, which can make the software noticeably slower. The effective monitoring provided by a developed system and used in a large range of application like fires, gas leaks, and for mining applications and if transformed for use in outdoor environment, applications like biological and chemical agent finding studies. In combination with ground sensors, the system may be used and integrated into a comprehensive monitoring of gas.

Elisabeth et al. in [29] said that automatic methods is required to achieve the cost-effective, reliable surveillance and locating of seeps in marine gas. At the floor of sea, seeps may be arised from sources of natural gas along with biogenic methane releasing from sediments and CO2 from volcanoes, or from structure made by humans like pipelines. If detection of seep is improved so estimation of the gases of greenhouse is possible which entering in the oceans, also by locate and address leakages economic and environmental sequences are reduced. Sonar is a tool excellently used for detection of seep due to its powerful acoustic backscatter characteristics of bubbled in water that is filled with gas. Previous methods for the acoustic seep location contain side-scan and multi-beam surveying, also passive and active sensors go up on platform which is stationary. In this paper, for detection of seep automatically using sonar interferometric side-scan. Author use signal processing method with knowledge of spatial and acoustical properties related to seeps for the improvement of detection. Fills some important gaps of previous techniques in given work, capability to find a seep while a signal passing by the use of AUV which have a sonar interferometric side-scan. Results of simulation also data of two leakage deserted wells which is in North Sea shows the minor seeps are frequently detected on a seafloor which is sandy even in case of limited duration of time. Also inspect capability of detection for various kind of seafloors. Explicitly network's life time, and end to end delay is not considered. Also, no related discussion or achievements in terms of that are given.

Han et al. said that the recent years, rapidly growth of making autonomous underwater vehicle-aided (AUV-aided) data collection strategy in underwater acoustic sensor networks [30]. If AUVs are efficiently used it reduces the sensor nodes' energy utilization. Main contribution are: i) To reduce the delay in data collection, a simple algorithm of machine learning KRR has selected for the data prediction. ii) To safe from packet loss, the AUV perform route planning that based on competitiveness coefficient of the request cluster. iii) Through bidirectional search, updated request sent by request cluster to overcome the excess of broadcast control message. It is hard to use multi-hop transmission because long distance transmission in underwater aggravates load of node. In comparison, by shifting their own energy utilizing to that of the AUVs, the node's energy can be maintained in a best way. In this work, proposed a prediction-based delay optimization data collection algorithm (PDO-DC) to reduce the delay in data collection. Unalike to conventional algorithms for delay optimization, Kernel Ridge Regression (KRR) is utilized to acquire the related prediction models through cluster member nodes. Further by visiting less cluster head nodes, the AUV can acquire data of all clusters, which may efficiently minimize the delay in collection by the AUV. As compared to the transmission by multi-hop, data gathered by an AUV at a near range get a less error rate. The use of AUV is also a more practical solution for data collection from underwater. Experimental results indicate the proposed method is effective as well as feasible.

Allibert et al. in [31] said that an image-based non-linear visual servo control technique for pipeline leading of fully-active Autonomous Underwater Vehicles (AUV). The pipeline's Plücker coordinates which are bi-normalized identified in plane of image are utilized as input information while the dynamics of system in the under-control configuration are utilize in cascade manner. Pipelines that are underwater are usually utilized for transferring of gas, oil or some other fluids from one to another place. In the ocean's depth severe conditions are presents (pressure, temperature, heat, mud, salt, vibration, etc.) which can lead to various issues like crack, corrosion, shock loading, joint breakdown and leakage. Frequent inspection, surveillance and repair of pipelines is thus strongly recommended for the purpose of safe operation. In discussing paper, the pipeline-following issue for AUVs mostly addressed by either an acoustic sensor or monocular camera; acoustic sensors like side echo sounder or scan sonar (SSS), is revisited. Control targets often include of vehicle's steering above pipeline and controlling its forward speed to reference value which may be specified or through human operator in advance or online. Most of the recent work related to this topic has been dedicated to the detection of pipeline by SSS image or camera image and to derivation of AUV's relative position and heading (up to factor of scale) regarding to pipeline. The given control technique accounts for whole dynamics of system to achieve the expended demonstrable stability area, unlike conventional technique which just consider system kinematics. By using the integral corrections, control robustness in respect of model uncertainties also external disturbance. In the given method efficiency and robustness are shown by both experimental results as well as real simulation on AUV which is real.

Bingxi et al. described a mission planning approach in discussing paper for the detection of oil spills through using several autonomous surface vehicles and autonomous underwater vehicle (AUVs) [32]. The deployment of various marine robots gives the chance for water's autonomous sampling and detection of leakage more efficiently. This paper's contribution is to design of strategy of deployment utilizing several underwater vehicles as well as charging stations for monitoring of oil spills. To reduce the expenditure of energy, underwater vehicles' trajectories and positions of charging stations are together optimized. This technique gives the chance for analysis of cost trade-off against performance of mission of detection of oil spills. Assume the big operational area for survey missions and surveillance, the manual recharging and endurance is a major limitation. The constraint of energy are taken into consideration, in discussing work given planning strategy for the battery recharging by using charging stations. To improve both AUVs and ASV's trajectories with position of stations of charging, given approach utilizes a Genetic Algorithm (GA) to reduce the energy cost and completion period of task. To check the performance and demonstrate the capabilities, a simulation performed on scenario based on realistic mission. The algorithm for planning a mission is take on to various mission sizes, environmental restrictions, vehicles type and count. The given technique is adaptable to multiple mission cases and multiple combination of robots. The research group is conducting field studies to incorporate acquired trajectories for an ASN and AUV and station of charging for similar scenario of mission. Also built and will be applied in nearing is the application of the given approach to 3D schemes to localize and track the leakage.

Shukla et al. in [33], said that this work shows of unmanned aerial vehicle (UAV) by automatic navigation for gas and oil pipeline's inspection. Continuous monitoring is needed because transferring of toxic and inflammable material through pipelines. For external examination of pipeline, UAV fitted with sensors which are non-contact are used. Lots of UAVs are utilized for monitoring, at elevated altitude and ground structure are monitoring like pipeline, but similar system may not be feasible for UAVs which are low-flying. In given automated technique whole study is done in real time, as UAVs' navigation itself relied on visual data of real time. Overall process of automation is classified in four sub parts: from image stream extraction of interest points, structure's detection which is for inspection, and the configuration of controllers for structure's tracking and automatic navigation. Compared to high altitude monitoring schemes with good quality camera, this technique contains better timelines and much challenges because of limited visual area. This research work suggests two new layers of UAV tracking and navigation by UAV. The two stages are here, first is pipeline detection and second is low-altitude pipeline monitoring. Pipeline detection and monitoring as linear framework which is image processing-based schemes without any GPS based localization instance. Autonomous tracking and navigation further have control loops of two layers, layer one is angular correction and layer two is lateral correction. Both controllers are based on basic PID controller which are heuristically tuned. In respect of visibility and stabilization of traced structure by the UAV's bottom camera.

Petraglia et al. discussed that for the identification of a number of events, such as internal turns and coating exposure, automatic examination of underwater pipes has become an activity of increasing significance, which may suggest risk for leakages in future [36]. Video inspection, most commonly carried out by underwater autonomous vehicles, may benefit from image recognition, assessment and machine learning techniques in respect to identify and classify those occurrences accurately. This paper discusses algorithms that are designed for pipeline segmentation and point out those important events. Various image processing techniques and monitoring methods are utilized in respect to achieve a stable detection of pipeline boundary in different cases. For classification purpose of four kinds of incidents, algorithm of wavelet-based multilayer perception and deep convolutional network (Deep-CNN) have been developed. The CNN technique where a big number of samples are used for training, performs better than perception algorithm for multiple incidents classes and except needing feature extraction manually.

Vibhav et al. in [37] Pipelines which are in subsea are critical offshore assets facilitates gas and oil transferring. In order to determine their integrity, routine checks are required to ensure continuous usage and prevent possible damage to ecosystem of marine. This real-time algorithm for near proximity pipeline detection and monitoring by using just a multi-beam echo-sounder including noisy measurements is given in this scheme. The provided method of detection gives accurate detection of pipeline also estimate pipe's orientation. The tracking scheme filters out robustly the wrong alarms produced by the algorithm of detection. Although, to make a comprehensive system of pipeline tracking, a sonar is utilized to supplement the given technique for long range approach and search. To check the feasibility of the given algorithm, detailed field experiments are conducted. Explicitly energy efficiency, network's life time, and end to end delay is not considered. Also, no related discussion or achievements in terms of that are given.

Han et al. said to enhance the efficiency of sensor network and ensure the high availability of data gathering service, a high-availability data gathering technique depends on various autonomous underwater vehicles (AUVs) (HAMA) is given [38]. Inside the network, various AUVs travel and their path is already defined. The nodes who are near the AUV's trajectory transfer their data directly to AUV, while other nodes forward their data to those which is near the trajectory. Contributions of this work are follows: 1). For the AUV's malfunctions probability model is created. 2). Scheme for gathering data with various movement model of AUV and various AUVs. 3). To ensure the increase availability of the data gathering scheme, AUV fault discoveries and maintenance techniques are given. To ensure that the networks work correctly when AUV don't communicate with nodes while gathering data, fault discovery and repair procedures are implemented. The given HAMA approach improves the packet distribution/sending ratio and the lifespan of the network as comparison of existing techniques. To ensure reliable transmission of data, a time mechanism that is reliable was utilized in HAMA. Explicitly larger average delay is experienced. Need to be resolved in future work.

Sheng et al. in [39], for the autonomous underwater vehicle (AUV) pipeline identification, a clustering-algorithm for pipeline feature based on binarization image pipeline linear extraction of feature is suggested in respect of conventional Hough transformation, and a K-means algorithm for clustering is include to identify the line corresponding to limitation of pipeline's location. The frame picture of recognition region in the last location of the central axis of the pipeline will be acquired accordingly. Pipeline monitoring by AUV image geometric model established then absolute pipeline's location can be acquired by following the transformation of geographic coordinate of AUV transform. To locate the pipeline, estimation of position technique is given which based on identification of pipeline, then the latitude and longitude of pipeline with saved data related to frame. To check the suggested algorithm, author conducted a pool experiment. Explicitly energy efficiency, network's life time, and end to end delay is not considered. Also no related discussion or achievements in terms of that are given.

Sam et al. in [56], shows a system of autonomous robot designed to search for and geo localize possible archaeological underwater sites autonomously. The system requests a pipeline which is multi-step, depends on AUV's. First, to gather data of less-resolution side scan sonar, the AUV builds a high-altitude scan along a big area. Second, to detect as well as identify potential interest sites automatically, software of image processing is used. Third, each site is assigned significance scores. Fourth, in order to obtain sonar data with high resolution, an AUV route planner is utilized to design a time-limited route which traverse places of high significance at less-altitude. Fifth, to pursue this route, the AUV is created. During the survey of archaeology located with the Malta coast, this technique was applied and tested. These studies have shown that the device can reliability and easily classify important archeological sites in a wide area that has not been surveyed previously. The proposed mission have culminated in the historical plane's discovery location was unknown previously. Explicitly energy efficiency, network's life time, and end to end delay is not considered. Also, no related discussion or achievements in terms of that are given.

Tsai et al. in [64], said for decades autonomous unmanned vehicles (AUVs) have been utilized for many purposes like shipping, military, etc. Autonomous vehicle has also expanded scope for the sensing applications following the artificial intelligence (AI) advancement. Sensing system AI based just not minimize data operation complexities, also give results for real time sensing. The architecture and implementation of an ASV with the AI dependent sensors are demonstrates in this scheme. Autonomous sailing, 3D smart sensing, remote communication and image detection, identification in a real time are the features of given ASV. Moreover, the ASV may also sail in shallow or unsafe waters. Validating the given systems' performance the results of experiments are presented with. More developments in AI dependent sensing applications can results from design of ASV's open module. Explicitly energy efficiency, network's life time, and end to end delay is not considered. Also, no related discussion or achievements in terms of that are given.

Mano et al. due to many advantages, such as limited transmission latency and multi-path fading inconsiderableness, magnetic induction (MI) transmission is an encouraging technology for the underwater sensor networks (USNs) [55]. However, the bulk of MI relay implementation techniques concentrate on 1D also 2D networks. An efficient relay creation algorithm is given to place the relay nodes in 3D USNs. For stability in amount of sensor nodes of every clustering space, the K-means is utilized to network's space division. Moreover, to save resources the relay nodes' position is important. A gradient descent algorithm is utilized to get the relay nodes' best coordinates to resolve this problem. Numerical analysis reveals that a practical implementation technique is the given algorithm. Explicitly network's life time is not considered. Also, no related discussion or achievements in terms of that are given.

Abu et al. said due to its high-resolution imagery and since its independent resolution of range, author gives a novel unsupervised statistically dependent algorithm for the underwater objects' detection in synthetic aperture sonar (SAS) imagery [61]. As compared to other approaches which don't use the statistical model of shadow area, given algorithm utilizes a shadow detection and ratio of weighted likelihood, thus leveraging the predicted spatial divisions of objects. A representation of higher order statics of an image, segmentation process followed to make a region of interest (IR), recognizes highlights. Also for every ROI, utilized a support vector machine (SVM) along the statistical features of ROIs' inside pixel to recognize background pixels and shadow related pixels, considering scan angle and sonar elevation. Given algorithm is robust as well. Additionally, knowledge of size and shape of target is not required, making given algorithm suitable for sonar types and detection applications of sonar. 270 images are gathered to access performance, also share with community. Given algorithm gives a trade-off between the rates of false alarm rate (FAR) detection probability relative with the benchmark technique. Explicitly energy efficiency, network's life time, and end to end delay is not considered. Also no related discussion or achievements in terms of that are given.

Han et al. in [62], said when underwater acoustic sensor networks (UASNs) advent, it increased the monitoring of marine environment, auxiliary navigation, as well as defense of marine military. Data gathering is one of the main UASNs' function. However, modern schemes for data gathering from underwater are typically face issues like high latency and more energy utilization. In addition, the use of multiple autonomous underwater vehicles (AUVs) has led to task assignment and also load balancing concerns. That leads to notable failure data controlling and gathering of unplanned emergencies. A district division-based data gathering algorithm with dynamic competition of event in proposed UASNs. The packet's information value in given algorithm specifies its transmission priority to the head of cluster. The geographic region division specifies the navigation location of the each AUV's area and the sink. Afterwards reinforcement learning is utilized to plan the AUVs path in sub region. Several AUVs are utilized to deal with emergency event. The simulation reveals that given algorithm gives energy efficiency and less end-to-end delay.

Wang et al. in [63] that the Autonomous underwater vehicles (AUVs) have a key part in oceanographic surveys and subaqueous construction, in which important component is self-localization of AUV. Current methods of localization depend on the costly system of acoustic positioning, which restrict the broad implementation of AUVs. In given scheme, underwater self-localization approach depends on Pseudo 3D vision inertia for AUV, suggesting to cost efficient visual localization approach and focusing on problems due to environment of underwater. In respect to achieve continuous and stable localization, proposed approach which incorporates information of depth in visual 2D image. Online fusion technique depends on nonlinear optimization tightly couples for measurement fusion of the already integrated inertial measuring device and down camera's observation to minimize errors. To enhance the accuracy, design a loop online detector to underwater relocation's realization. Developed a cost efficient, compact, and for underwater vehicle small sensor suite, and validate given method. Author utilize the sensor suite which is custom made, and experimental findings demonstrate the effectiveness of the given method in an unpredictable underwater environment. Explicitly end to end delay is not considered.

2.2.3 Swarm Intelligence Based Schemes

Kaur et al. said in [24], the primary problem is energy efficiency in WSN. Sensor nodes (SN) use battery for energy, but died when battery is empty. It is difficult to increase the lifetime of SN. To increase the WSN's lifetime, two aggregation techniques are used which are tree and clustering based. This scheme gives a Hybrid Ant Colony Optimization (ACO) and particle Swarm Optimization (PSO) based energy-efficient clustering and tree-based protocols for routing. Large-scale analysis disclose that the given technique enhances the life of network than other techniques. Monitoring techniques that use internal sensors are discussed here; i) Acoustic Sensors: These are used to find a leakage in pipeline, but its limitation is that it is useful for small leakage. ii) Transient based techniques: For find the location and size sensors are used known as pressure sensors, but limited number of sensors are deployed with pipelines; this thing reduces the accuracy of technique. iii) Mass balance methods: A type of sensors used to observe the differences in flow for the purpose to locate leakage within system. But when the flow is change, then the detection is done by this method is incorrect. Also, this technique does not have the capability for finding the position of the leakage [4]. Multiple types of sensors are used for different fluids which is transported through the pipeline. For instance, leakage of water is found through using humidity sensors, and in pipeline of natural gas hydrocarbon vapor sensors are used.

Yandja et al. in [47] said the transport and delivery of gas, oil, water, etc. is commonly used by network of pipeline. Pipeline bursts and leakage occurs regularly due to these devices' deteriorating. Therefore, in respect to provide detection at early levels of sudden issues like leakage, before they reach on extreme level where it may reason of major disaster, so continuous monitoring is required for that systems. To accomplish this aim, WSNs comprise of sensor nodes which are low-cost, low-power utilization, and multifunctional for monitoring environmental conditions, are presented as an appropriate technology. Efficiently energy utilization is an essential factor in helping the operation of network for a long duration as possible. Also, another significant factor is network throughput to sustain the QoS of network. Main contributions: 1) Multi-objective Chaotic Ant Swarm Optimization (MCASO) based model for energy efficiency, and increased throughput. 2) Combine K-Means++ for process clustering. 3) Single CASO extends to Multi-objective CASO. The simulation results affirm the increase the lifespan of network and maintenance of QoS.

2.2.4 IoT Based Schemes

Elleuchi et al. in [34] said that the leakage identification and water pipes' location is one of the key issues in the water protection area. In recent years, water pipeline monitoring (WPM) gain attention worldwide because need to reduce cast of water production also to secure public safety. A big contract of research has attempted to suggest a solution to the detection of water leakage. The given solution use hierarchical model. In this technique various kinds of sensor nodes like nodes which is normal sensors connected and, on the pipeline, placed, nodes that are cluster head (CH). Based on the three moisture sensors and utilizing real cases in real scenario, author gives a novel leakage experience. Experience depends on ARDUINO MEGA's three moisture sensors. A novel based on moisture of soil sensors and MEGA Arduino as a microcontroller. In this scheme, to find the leakage soil's moisture percentage is measured. Multiple experiences are make for determine the best solution to find the location of leakage and the time. Varieties of different leak cases were carried out during the experimental trails and at different leaks places were examined. The finding shows the given solution is capable to run stably and find the leak. Explicitly no algorithm and any equation is given. As well as no graph for representation of results.

Abdelhafidh et al. in [41], said the water Pipeline Monitoring System (WPMS) is incredibly important assuming the big water due to leakage and some hydraulic failures/faults. Accordingly, designing a precise water management system shows a crucial task which implements serious analysis and adequate preparation specifically in industrial domain. Internet of Things (IoT) based on physical object and intelligent sensor network is applied to manage the water distribution system, and to deal with pollution of water during supply. Given system is with its details of layered architecture which is implemented is highlights. Author describe the key tasks and objectives for each layer, either that are implemented or in future it will implement. Phase of assessment is very important to choose a level of accuracy. A wide variety of industrial IoT (IIoT) techniques have recently been created and deployed in this field. In this article, author gives a distribution system for water which is based on IoT, to identify and locate leakage in system of water pipelines. For performance evaluation, gives a phase of assessment.

In [42], Abdelhafidh et al. said with respect to secure the world from wastage of water, monitoring system of water pipeline is effective way to deal with various hydraulic failure of pipeline. In this regard, intellectual water distribution system (WDS) mixes Big Data with IoT produced by multiple connected objects and machines for monitoring of pipeline's structural health reliably. Therefore, it takes analysis and proper planning to design a flexible WDS with smart detection of leakage. Author gives a cognitive architecture based on IoT, with sufficient collection of data based on framework of Apache Spark. In addition, goal of paper is to create mechanism which is hybrid, by considering the transient and steady-state actions of water to identify and perform precise leakage and detection and localization. Centered on genetic algorithm, sensitivity bio-inspired analysis of the pressure of water profile guarantees the feasibility and precision of the monitoring approach proposed. Explicitly networks' lifetime and end to end delay is not considered. Also, no related discussion or achievements in terms of that are given.

In Chenxing et al. in [43] said the monitoring network for gas and oil pipelines uses IoT by automated surveillance and systematic management of equipment like cutting the valves and system for cathode safety to ensure secure operation in unattended and remote area. The stability and connectivity of power supplies for various IoT surveillance platform d gas and pipeline are crucial. In all various situations, there is not any alone universal off-grid supply method which is suitable for gas and oil pipeline monitoring IoT platform. Therefore, according to particular geographical location, meteorological conditions it is necessary to choose a suitable one. This paper gives an off-grid, reversible solid oxide fuel cell (RESOC), photovoltaic (PV) and power battery power supply system. The main goals are minimum running costs and efficiency of system service under restricted conditions. A "RESOC + battery + PV" optimized system operation model is developed. Three types of power supply techniques which is off-grid are recommended depending on model, and geographical three locations with varying conditions of environment are chosen application scenario that are realistic. Matlab Cplex is utilized to resolve the three regions' various models of power supply. Eventually under various geographical environments and conditions of environment, power supply technique with best flexibility, economy is acquired.

Abdelhafidh et al. in [44], assuming the many pipeline losses and the different hydraulic failures which cause vital loss of water, the Water Pipeline Monitoring System (WPMS) is most important. In this case, intellectual Water Distribution System combines IoT with efficient analytics of Big Data for robust and intelligent pipelines' Structural Health Monitoring (SHM). Contributions are: 1) Defining and detailing a WPS architecture base on IoT utilizing a solution of big data which is capable of controlling and managing studied WPS. 2) More focus on functionalities of IoT Remote Control Center Layer, where performance test of simulation of hydraulic transient is done. In this article, author suggest an intellectual architecture based on IoT which uses Apache Spark structure to manage to manage the vast volume of data generated by processing in a real time. The effective measured data analysis and the resulting estimated values simplify transient simulation and leakage detection, making it easier and faster. Explicitly energy efficiency, network's life time, and end to end delay is not considered. Also, no related discussion or achievements in terms of that are given.

Priyanka et al. in [45] said the control and surveillance system are required in the current upgrade period to secure the seamless running of the ling-distance pipeline in the liquid transport system. A crucial activity which involves proactive preparation in the transportation environment of liquid is to design correct surveillance and control system. A crucial activity which involves proactive preparation in transportation system for liquid is to design of a precise online control and surveillance system. The tremendous quantity of leakage of liquid due to leaks, blockages and cracks due to significant pressure changes during transport of liquid in the system of pipelines. The focus present work is on the development of an intelligent automated architecture based on IoT to perform monitoring, flow rate, and pressure management online in the transportation system of fluid. LQR-PID controller with SCADA is kept as local intelligence or control unit through the architecture based on IoT which is integrated. Due to extreme changes of flow rate and pressure, PID controller with SCADA can't be afford the control action which is wished during leak and crack events in the pipeline. Therefore, by online high-level IoT interface server is for tracked and accessed to detect cracks and leaks of the pipeline at its initial stages, other it creates disastrous situations.

Lee et al. in [48], by utilizing ZigBee technology created the IoT-based monitoring system for safety of bridge. The scheme is made of: (i) surveillance equipment are deployed in bridge environment; (ii) communication devices linking the bridge surveillance devices and cloud-based server; (iii) data of bridge condition is stores in database which is dynamic; (iv) a server based on cloud which measures and analyzes the information which is send by transmitted devices. This technology will track and interpret the bridge's conditions and its surroundings, including local nearby water level, air, and pipes, and safety condition, in real time; as well as send alerts to staff of bridge management for the purpose to induce reactions. Images and data recognized are send to database and server so that users can track the bridge's condition in real-time using telecommunication mobile devices. This system will allow safety management of bridge 24x7 also suitable and timely responses in case of emergency. Additionally, as an auxiliary power source used a solar power for the lamps and system on bridge, helping to conserve energy and reduce carbon emission.

Elleuchi et al. in [52] said that owing to previous technology improvements, the IoT has drawn interest in previous years. The main motive of IoT is to connect objects to the world through the internet, so that they can automatically exchange information. Many security challenges have arisen, though. A lot of academic work is therefore directed at proposing ways to improve the level of protection in IoT applications. A research work's great deal is it to give solutions to improve the protection level in applications of IoT. From these applications, most depends on RPL like a routing protocol. In respect to maintain consistence, RPL provide routing data which is unmodified, and check the routing data that comes from registered machines to conform authenticity. In this article, protection scheme for the routing protocol based on RPL-IoT. For distribution of symmetric keys identity-based cryptography is utilized. As application consider the monitoring of water pipeline, thus retaining low power usage. For performance evaluation and simulation, use as an operating system CONTIKI and Cooja tool simulation. Author illustrate that this technique is light weight as well as not add hog overhead resources and memory. Afterwards, it can support restricted IoT devices while preventing several routing attacks.

Dan et al. in [65] said that in United States (US), water delivery networks link raw water supplies to billions of water users through enormous infrastructure which comprises almost million miles of underground mains of water and service links and lot of treatment equipment and facilities. Currently this big setup operated greater than 170,000 water systems for public. There are lot of impending problems facing water supply system. Current, practices in water supply management, however, are not giving priming solutions to the problems mentioned above. The new concept is Big Data for gathering vast volume of related data placed sensors designed to monitor conditions of the structure, utilization, and performance of system. Through implementation of IoT in water supply system for the utilization of customers, this concept of Big Data may be realized. This work gives a schematic IoT applications' development for the Big Data gathering by a multitude of water clients. The scheme comprise of downstream as well as upstream data gathering utilizing IoT connected to wireless sensor network (WSN). Downstream data gives water utilization and output, also upstream data. Ultimately, to construct a Big Data gathering system. The aim of discussed development to enable utilities as well as utilizers to manage their water utilization and get higher standards of water supply sustainability.

2.2.5 Hybrid Based Schemes

Abdelhafidh et al. in [57], said that the monitoring system for controlling of underground pipelines is a complex task which requires serious analysis and comprehensive investigation. Therefore, given the tremendous environmental and economy damages incurred by leakages, pipelines' monitoring in industrial environment for reliable gas and water delivery is crucial. Hybrid monitoring methods are utilized to deliver a robust leak detection which overcomes the challenges of traditional methods and enhance the process of localization. In this article, the hybrid mechanism is to locate and detect the leakage location of a pipeline on basis of wave propagation process and real time transient modeling. To sort out the leak detection model depends on transient, a mathematical model is executed and various scenarios are created to approximate the relationship between the fluctuation of pressure and leak's position. The obtained findings approve the potential of the scheme proposed. Explicitly network's life time, and end to end delay is not considered. Also, no related discussion or achievements in terms of that are given.

Karry et al. in [59], said huge water amount are lost daily because of pipelines' leakage. Latest technologies should be utilized in respect to reduce the waste and save water. In this regard, a wireless sensor network (WSN) is growingly required for optimize inspection efficiency and increase the accuracy of monitoring of the water pipeline. In order to track and identify leakage on long distance pipelines, a solution is given by author through using WSN. It mixes localization algorithm and leak detection an effective wireless sensor node architecture system on chip (SoC). A novel water pipeline monitoring (WPM) proposed, which used leak detection kalman filter (LPKF) and updated time difference of arrival (TDOA) technique depends upon pressure measurements. Rather than using various algorithms which deeply damage the node's battery, nodes' data are analyzed, compressed and filter with the kalman filter (KF) dependent algorithm. Save the sensors' node power, local pre-processing low power is efficient. In addition, built a laboratory testbed utilizing plumbing materials also tested by pressure sensors with ARM dependent prototyping platform. Explicitly network's life time is not considered. Also, no related discussion or achievements in terms of that are given.

2.2.6 Miscellaneous Based Schemes

Wang et al. in [49], 3D electromagnetic dispersion model (EM-model) may foresee matching features at various angles, which plays a vital role in the detection of automation targets for the framework for synthetic aperture radar imagery (SAR-ATR). However, occurrence of mismatch of space is between measured image and the model. The measured picture and EM-model are in different system coordinate. This article gives a novel algorithm for spatial misalliance depends on EM-model. Author take dispersing center a main feature, assuming the model characterized by amplitude and the position of scattering center (SC). The model's measured data dispersing centers are independently extracted, and Hausdorff distance (HD) is utilized to distance measure between measured picture and EM model. The relation between measured picture and EM model, the corresponding of rigid transformation is developed. The viability of the given algorithm is shown through experimental results depends moving and stationary target acquisition and recognition (MSTAR). Experiments demonstrate that there is strong adaptability compound operations of the spatial rectification algorithm. In an environment of complicated, it is also used and the basis for more correct recognition is laid.

Khawar et al. in [50], discussed that there is an immediate need for creative and efficient strategies to prevent incessant pipeline accidents attacks, considering the growing number of accidents across the world. As they may be utilized to measure, recognize and give applicable information on physical properties of pipeline like temperature, video, pressure, gas and oil motion and also environmental parameters. This article presents identification of modes order to pipelines' surveillance depends on architecture of integrated system. The Multi Agent System (MAS) utilizes by given architecture in order to realize the Integrated Oil Pipeline Monitoring and Incident Mitigation System (IOPMIMS) which can efficiently track and give applicable pipelines' information. The various threats for pipelines and various detection methods are shown in current article would make a better placement of incident mitigation pipeline surveillance system. The limitation of existing sensor wireless nodes as regarding to their use for surveillance of pipelines are not being efficient for systems of surveillance. The resulting criteria includes a basis for the construction of a cost efficient device, mindful of the consideration of design utilized in pipeline surveillance for unwired sensor motes. Explicitly no algorithm and graphs are given in this article.

Lin et al. in [53], gives a technique which uses a spherical detector (SD) with a tri-axial accelerometer to detect the subsea vibration of spanning pipelines. Mathematical experiments and analyses reveal that the acceleration modulus square

(AMS) AC component of AMS (AMS-AC) of the recorded acceleration signal through the SD have a single part characteristic which have a frequency is equivalent to pipelines' vibration frequency and also can be utilized to determine it. Because this component's amplitude is insensitive to SD's rotating noises, its noise ratio of signal is greater than other components that have frequencies are the mixture of rotation and vibration frequency. To have AMS-AC have the special frequency to signify the vibration of pipeline, the elimination of the DC bias through the three axes which are sensitive will remove other predictable frequencies. Through utilizing AMS-AC, the frequency of the vibration can be sensitively and correctly defined. The detection limits for 5Hz, 10Hz, and 15Hz are 0.6mm, 0.4mm and 0.2mm respectively, in respect of amplitude. Explicitly energy efficiency, network's life time, and end to end delay is not considered. Also no related discussion or achievements in terms of that are given.

Mano et al. in [54], said significant incidents due to sewage pipelines' aging current occur regularly. Author created a peristaltic crawling inspection robot which duplicates the locomotion of an earthworm's. This robot is able to move greater than 100m inside the sewer pipe and done maintenance (100A pipe). Generally, pumping pipes have complex pipelines. Robot has strong traction force, for large distance driving this robot is not sufficient. To handle the robot's load feedback were added. It is proved through regulate the timing of operation, higher traction strength is achieved. Explicitly energy efficiency, network's life time, and end to end delay is not considered. Also, no related discussion or achievements in terms of that are given.

Anbari et al. in [58], said as urban infrastructure are one of the most important infrastructure in waste water system, the detrimental effects and results of inappropriate output and breakdown incidents can also interrupt the operation of part of community. By defining high risk of failure areas, checks can be executed on the state of the infrastructure and can therefore significantly improve the efficiency of the sewage network. New model of risk management was built in this analysis to prioritize the inspection of sewage pipes utilizing Bayesian Networks (BNs) like a probabilistic approach to calculating the probability of break-down and weighted average method to measure the failure values' outcomes. Finally, the likelihood of a sewer pipe is acquired through the probability integration and failure results values utilizing a fuzzy inference system (FIS) to assuming uncertainties. Sewer pipelines of a municipal wastewater gathering network which is in Iran, are prioritized for review on the basis of their criticality, as a case study. Most sewers (about 62%) have an ordinary risk, but sewer 12% are in a critical situation. As budget constraints are concerned, it is anticipated that the given model and the resulting values of risk will help wastewater agencies restore or replace hazardous sewage pipes, specifically in dealing with uncomplete and undetermined datasets. Explicitly energy efficiency, network's life time, and end to end delay is not considered. Also, no related discussion or achievements in terms of that are given.

Wen et al. in [60], said vibration sensor which is of optical fiber Loop Integrated Mach Zehnder Interface (LMZI) was given for implementation of pipelines' monitoring and leakage recognition. Utilizing the torsion sensitive LZMI sensor, vibration sensor depends on the power demodulation technique. The sensors are cost-effective, not conductive, has limited criteria for configuration and is like sensitive in respect of vibration sensing like an industrial acceleration. The sensor's reliability was experimentally proven by good response on vibration is shown by sensors in the characterization of frequency. More fundamentally, during field evaluation, the sensor was able to both flow also leak induced frequencies. Compared to commercial accelerometer, the observed leak induced frequencies that were compared and demonstrated good alignment with percentage variations of 0.4%, 2.64% for the 2, bar leakage respectively. LZMI sensors are alternative leak detection that has considerable potential for the possible substitution of existing traditional sensors. Explicitly energy efficiency, network's life time, and end to end delay is not considered. Also, no related discussion or achievements in terms of that are given.

2.3 Summary of Schemes

In this section summary of schemes which are in the literature review are given. Network's life time, end to end delay, achievements of schemes [40], [44], and [59] which are energy efficient and summary of schemes are given below in Table 2.1.

Table 2.1: Summary of schemes

Scheme names	Main idea	Method	Advantages	Limitation
EULWSND [20]	Robust nodes deployment scheme for monitoring of underwater pipeline	Give algorithm for nodes deployment.	Lower communication overhead, enhanced packet delivery ratio.	Does not handle emergency event
ALSN [21]	Monitoring of underwater pipeline by usage of LWSNs	Present scheme	Flexible nodes placement, Reduce interference, and collision.	Consume more messages for communicati on
3D UWSN [55]	An efficient relay creation algorithm is given to place the relay nodes in 3D UWSN	K-means, and gradient descent algorithm, Gives Optimal relay deployment algorithm.	Efficient nodes deployment strategy in underwater 3D environment.	Network lifetime is not considered
HS-LRT [61]	Detection of underwater object	Gives a novel unsupervised statistically dependent algorithm for the underwater objects' detection	Use SAS for high resolution images, so get more clear idea about underwater things.	Energy efficiency, network's life time, and end to end delay is not considered
IS-WPMS [42]	Monitoring of pipeline's structural health reliably	Give algorithm for remote pipeline monitoring	Precise leakage and detection of pipeline.	Network's life time and end-to-end delay is not consider
IoT-WPMS [44]	Water pipeline's structural health monitoring	Give algorithm for valve opening percentage, and for pipeline detection.	Energy efficiency, network's life time, and end to end delay is not considered	Energy efficiency, network's life time, and end to end delay is not considered

WDEM [40]	Maximize lifetime and minimize energy of entire system of pipeline monitoring.	Give node placement for on-line pipelines monitoring application	Energy efficient, maximum lifetime	End-to-end delay.
EARNPIPE [59]	Track and identify leakage on long distance pipelines	Give LPKF algorithm	Energy efficient, leak location, estimation of leak size	Throughput
H-RWPMS [57]	To locate and detect the leakage location of a pipeline	Give algorithms for detection of leak, computing interior boundary points, and computing of downstream values of boundary	Locate position of a leakage	Network's life time and end-to-end delay is not consider
ACOPSO [24]	Energy efficient WSN's	Use algorithm ACO, PSO	Energy efficient, improved network lifetime	End-to-end delay is not considered

2.4 Summary

This chapter is about literature review and literature is divided into six categories. These are: heterogeneous based schemes, vehicle based schemes, swarm intelligence based schemes, IoT based schemes, hybrid based schemes, and miscellaneous based schemes. Also discussed are the challenges, issues and main contributions. Afterwards is a table in which limitations, advantages and main aim of the schemes of literature is given. Literature review is the main part in finding the issue.

CHAPTER 3

METHODOLOGY

3.1 Overview

This chapter is about methodology which is used to design and develop the underwater pipeline hazard monitoring and reporting in linear wireless sensor networks. Main aim of this work is to handle emergency scenario more efficiently than base papers. For that, created a system which handles normal (non-emergency) as well as emergency scenario more efficiently, by utilizing less energy through less number of messages for communication. In the first step, less number of messages are used. Heterogeneous structure is used to reduce the number of messages. Second step is when data is reached at AUV, and checking of the data is related to emergency or normal scenario, the specific task is performed accordingly. If data is related to emergency scenario, then as soon as possible to reduce/minimize the loss of material which flows through the pipeline, environmental as well as underwater habitat loss. Main objective of this work is to utilize less energy, less number of messages, delay of messages and life time of network.

3.2 Operational Framework

The operational framework is composed of two scenario. First phase is BSN collect data from pipeline and perform aggregation, then forward data to DRN, DRN then performs aggregation and forwards data to DDN. In second phase, AUV collect data from DDN and checks that data belongs to emergency or non-emergency, then performs next step accordingly, as mentioned in proposed solution. Operational framework is illustrated below in Figure 3.1.

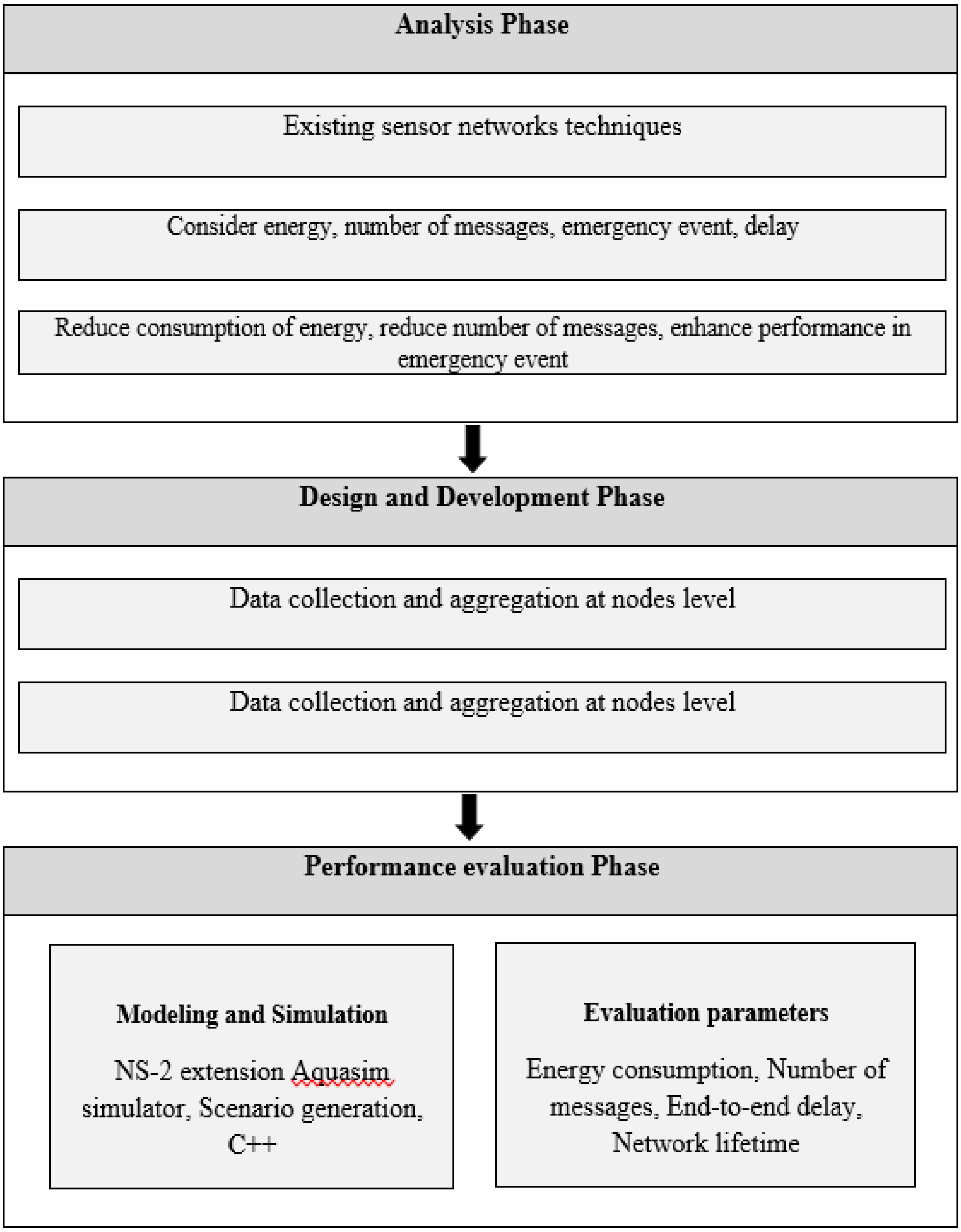

Figure 3.1: Operational framework of the research work

3.3 Research Design and Development

Solution of identified issues are introduced, which consists of two phases: one is data gathering and aggregation from base level to DDNs, second is from AUV to base station which includes data checking aggregation.

3.3.1 Collection of Data at Nodes Level

In this work, hierarchical nodes development model is used to reduce the number of messages. In hierarchical model, BSNs gather data from the pipeline and performs aggregation. After which forwards data to the RNs, which is on the higher level of SNs. RNs gather data and performs aggregation. Further forwards it to the DDNs, which are on the higher level than the RNs. DDNs also performs aggregation. Complete model for data collection at node level shown in Figure 3.2.

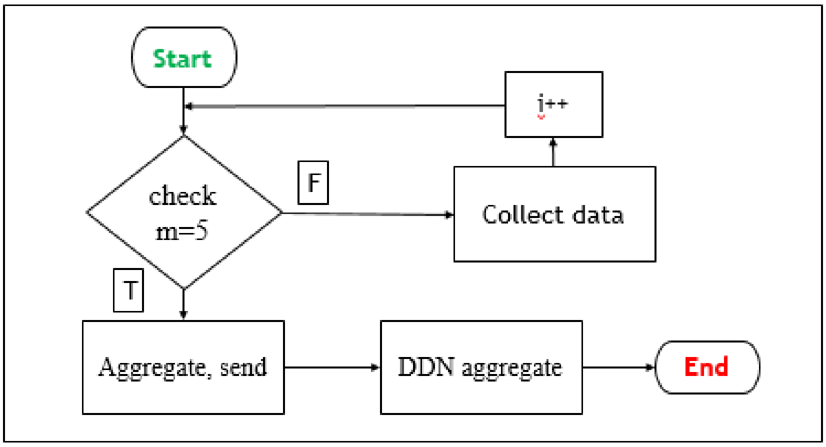

Figure 3.2: Data collection at nodes level

3.3.2 Collection of Data at AUV Level

AUV just collects data from DDNs and checks whether data belongs to emergency scenario or normal (non-emergency), then accordingly react. In case of normal scenario AUV visits every DDNs for data collection and forwards it to the sink. If data belongs to emergency event, then first step that AUV forwards data to the sink node. As data reached at sink, sink forwards it to the base station, model is shown below in Figure 3.3.

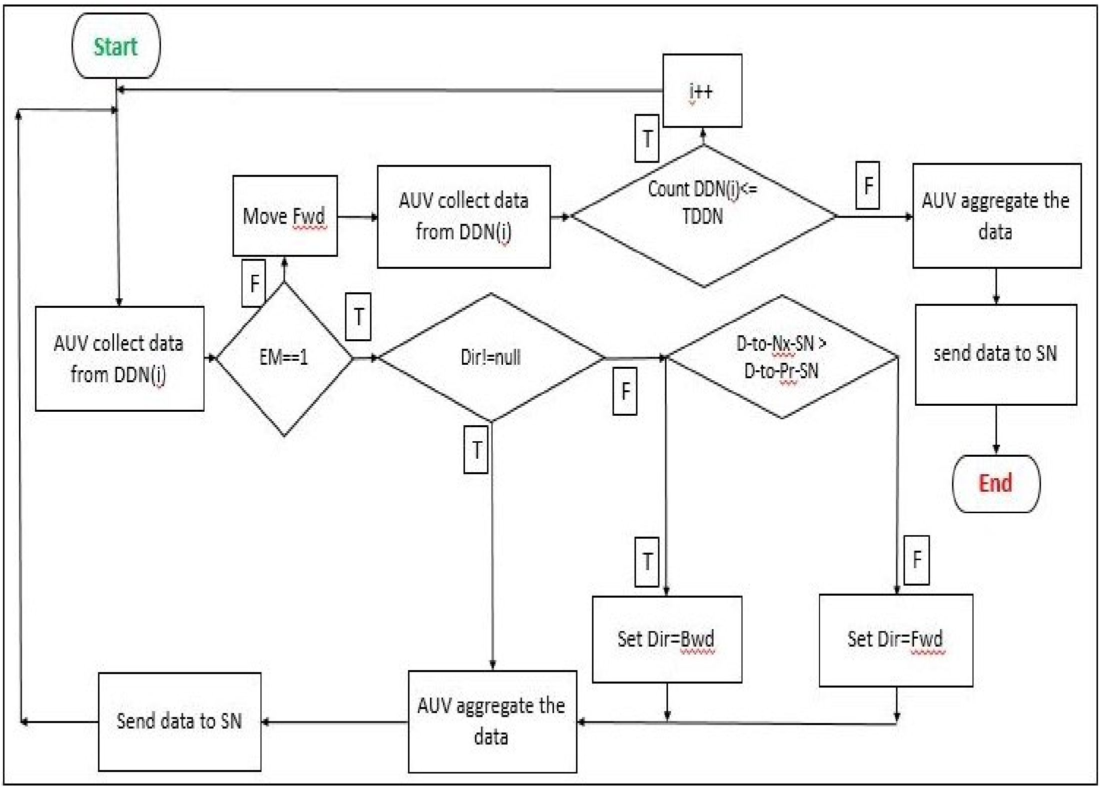

Figure 3.3: Data collection at AUV level

3.3.3 Normal (Non-Emergency) Scenario

As discussed in above section 3.3.2 when AUV receives data then checks whether data is normal or emergency event related. Now normal (no-emergency) is assumed. In this scenario AUV firstly collect data from all DDN'S and then forwards it to sink node. Maximum time is required for gathering of data, because in this case AUV starts gathering data from the very first node and traverse all nodes. Maximum time is calculated by: $TFSA(\max) = [(n-1)d]/s$. Minimum time in gathering of data, in this case AUV just gathers data from just one node or last node which is near to the sink which is calculated by: $TFSA(\min) = 0$. Average time of gathering data is calculated by: $TFSA(\text{avg}) = [(n-1)d]/2s$. To avoid dropping of messages given relation must followed by an AUV speed: $s <= [(n-1)d]/T$. To avoid loss of messages due to overflow of AUVs' buffer; consider it as a worst scenario, in this scenario AUV gathers data from the very first node and traverse all the nodes and reaches the node which is closest to the sink. It means all nodes (i.e. "n") are traversed by the AUV for the purpose of data collection.

3.3.4 Emergency Scenario

When AUV collects data from DDN which is related to the emergency, AUV firstly shares that data with the sink, instead of visiting remaining DDN's to overcome loss of material which flows from pipeline. As early as possible data is reached to the base station, possible action could be taken.

A case in which maximum time is required for gathering of data, because AUV starts gathering data from the very first node and traverse all nodes because it is assumed that emergency is occurred at the last node. Maximum time is calculated by: $TVSA(\text{max}) = [(n-1)d]/s$. Minimum time in gathering of data, in this case AUV just gathers data from the node which is nearest to the sink or just from first node. Assumed that emergency is occurred at first node, then AUV doesn't traverse further to any node, until reported to sink which is calculated as: $TVSA(\text{min}) = 0$. Average time of gathering data is calculated by: $TVSA(\text{avg}) = [(n-1)d]/2s$. To avoid dropping of messages given relation must followed by an AUV speed: s <= $[(n-1)d]/T$.

3.4 Parameters

Parameters which are used: the total SN's that are used for the whole network is shown by "n". The distance between any two SNs are presented by "d". The interval cover by an AUV passing by the SN, while SN's are in a range of communication with each other is given by "de". The communication range of SN is shown by "CR". The data size (in bytes) which is exchanged between SN and AUV represented by “B”. Also speed of AUV is presented by “s”.

3.5 Performance Evaluation

In this phase, Evaluation parameters as well as modeling and simulation is discussed. The presented model is discussed and tolls which are used for simulation.

3.5.1 Evaluation Parameters

We compare presented scheme with the base schemes on the bases of energy consumption, number of messages and delay. In chapter 5, Figure 5.7 shows presented scheme uses less number of messages than base schemes, so less energy is required for less number of messages and delay is reduced as well.

3.5.2 Modeling and Simulation

In this work hierarchical nodes deployment model is used, in this model data is reached from source to destination hierarchically. Presented model consists of nodes. At lower level BSNs are deployed, which share their data with DDNs. DRNs are deployed on hierarchically higher level than BSNs. Further DRNs share their data with DDNs which are placed above DRNs. AUV which is just a moveable vehicle that is on a higher level above than DDNs which collect data from DDNs and check data type either it is normal or related to emergency scenario. Further SN are collecting data from AUVs and sharing with Base station. Simulation is performed in NS2 which is suitable for simulation of underwater environment, by using C++ programming language. Aqua-Sim is used with NS2 to visualization of simulation in 3-D environment.

3.6 Simulation Framework

Current operational framework have three phases, as figure 3.1 shows. In the first phase existing schemes/literature is reviewed, because it helps in problem identification. Issues which need improvements are presented. Afterwards second phase is about given solution to resolve the issues which are identified in literature. Given solution consists of two phases, first one is data collection and aggregation at nodes level and second is collection and aggregation at AUV level. Further in third phase the given scheme's performance related to energy consumption, number of messages and emergency event handling. Also some details about simulation is given.

3.7 Summary

This chapter gives information about the problem, and then how we solve it. Also two phases, phase 1 is data collection at nodes level and phase 2 is data collection at AUV level of this work are gives and explain. Also phases are shown in a pictorial form. Also operational work as well as research design and development is shown in a pictorial form and explained. So, combined both phases show whole flow of work.

CHAPTER 4

PIPELINE HAZARD MONITORING AND REPORTING IN UNDERWATER LINEAR WIRELESS SENSOR NETWORKS

4.1 Overview

In this section, given model is illustrated to inspect the main data collection flow from the sensing nodes and to send it to the collector nodes. AUVs collect data and forward it to surface nodes. In this work a proposed mechanism for efficient data collection by using the fixed fixed/constant speed and dynamic/variable speed AUVs. Hierarchical data collection model is used in this work.

4.2 Pipeline Hazard Monitoring and Reporting in Underwater LWSN

To solve the identified problem, an underwater pipeline monitoring and reporting using LWSN is developed. Firstly, in data collection process reducing the number of messages as compared to EULWSND, by using hierarchical model. By using reduced number of messages energy is saved. As more energy is required for communication while using more number of messages, so given scheme uses less number of messages as a result energy is being saved. Secondly in emergency scenario, reporting of hazard in minimum time than EULWSND is a way to reduce loss of material, economy, underwater environment, and habitat.

4.3 Objectives of This Work

In this section objectives are discussed, which are achieved.

4.3.3 Reduce Number of Messages for Communication

As in this scenario, AUV collects data from DDNs. But in the ALSN, AUV visits every node for data gathering. ALSN used more number of messages for communication. While in PHMR less number of messages are consumed by an AUV.

4.4 System Model

Basic Sensor Nodes (BSNs) are deployed/placed in a linear structure and used to gather data from the pipelines, performing aggregation on that data. BSNs are shorter range and low powered, and perform aggregation on data. Data Relay Nodes (DRNs) have a high range and power compare to the BSNs. DRNs are present on higher levels than the BSNs. One DRN has a capability to collect data from the many BSNs, which are responsible to send data to it. Afterwards on a higher level of DRNs, Data Dissemination Node (DDNs) are placed; these are more powerful as compared to DDNs and BSNs. On hierarchy DDNs are on third level. DDNs done aggregation on data and send them to the Autonomous Underwater Vehicle (AUV) which is on higher level (fourth level) of hierarchy. AUVs are more powerful to the lower levels, and AUVs have high range. Duty of AUV is to perform aggregation on data and then send it to the surface sink (SS). Further SS performs aggregation on that data and forwards it to the network control center (NCC), as shown in the Figure 4.1.

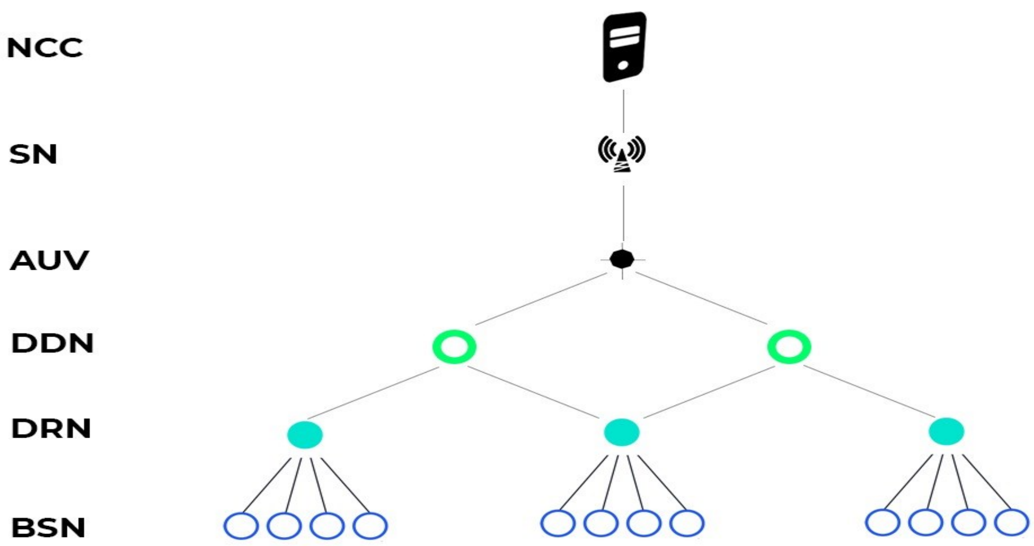

Figure 4.1: Proposed model

4.5 Proposed Scheme

In this section, the scenario of data collection is inspected through using fixed or dynamic speed of AUVs. Main aim is to detect and report the emergency event in a minimum amount of time and consume less amount of energy. In this work hierarchical model is used to reduce the amount of energy consumption as well as less amount of messages are used for communication. This scheme tackles emergency events by using lesser energy as well as lesser number of messages for communication purpose. Also hazards are reported in a less time as compared to the ALSN.

4.5.1 Fixed Speed AUV for Data Collection

In given scenario AUVs don't traverse every sensor node, AUVs just gather data from the DDNs; as DDNs gather data from DRNs and DRNs from BSNs. As a result energy loss is reduced. In the case of "fixed speed AUV", AUV gather data while it is moving with a constant speed. Afterwards AUVs send data to the surface sink. Also in this case emergency scenario is not considered and AUV move with a pre-defined speed. Parameters which are used are: the total SN's that are used for the whole network is shown by "n". The distance between any two SNs are presented by "d". The interval cover by an AUV passing by the SN, while SN's are in a range of communication with each other is given by "de". The communication range of SN is shown by "CR". The data size (in bytes) which is exchanged between SN and AUV represented by "B". Also speed of AUV is presented by "s".

Maximum time is required for gathering data, because in this case AUV start gathering data from very first node and traverse all nodes. $TFSA(\text{max}) = [(n-1)d]/s$. Minimum time in gathering of data, in this case AUV just gather data from just one node or last node which is near to the sink. $TFSA(\text{min}) = 0$. Average time of gathering data is calculated by: $TFSA(\text{avg}) = [(n-1)d]/2s$. To avoid dropping of messages given relation must followed by an AUV speed: $s <= [(n-1)d]/T$. To avoid loss of messages due to overflow of AUVs' buffer; consider it as a worst scenario, in this scenario AUV gather data from the very first node and traverse the whole nodes and reached the node which is closest to the sink. It's means all nodes (i.e. "n") are traversed by the AUV for the purpose of data collection.

4.5.2 Variable Speed AUV for Data Collection

In this scenario AUV gathers data from the DDNs, but as data of hazard is gathered AUV immediately shares it with SN. As a result energy loss is reduced. For "variable speed of AUV", emergency situation is assumed. Main aim of this scenario is if emergency situation like damage, leakage is occurred AUV doesn't traverse the further DDNs either they are remaining or not. Rather AUV immediately forwards emergency related messages to the surface sink. So, as a result lesser loss of economy and underwater environment occurs. A case in which maximum time is required for gathering data, because AUV starts gathering data from very first node and traverse all nodes because it is assumed that emergency is occurred at last node. $TVSA(\text{max}) = [(n-1)d]/s$. Minimum time in gathering of data, in this case AUV just gathers data from node which is nearest to the sink or just from the first node. Assumed that emergency is occurred at first node then AUV doesn't traverse further any node, until reported to sink. $TVSA(\min) = 0$. Average time of gathering data is calculated by: $TVSA(\text{avg}) = [(n-1)d]/2s$. To avoid dropping of messages given relation must followed by an AUV speed: $<= [(n-1)d]/T$.

4.6 Proposed Algorithm

In this section proposed algorithm is given as well as discussed. Algorithm is separated into two phases, phase 1 is data collection at nodes level. While the phase 2 is data collection at AUV level.

4.6.1 Data Flow at Nodes Level

BSN gather data and execute aggregation and transfer that data to RN. RN performs aggregation then sends data to DDN. Further DDN also execute aggregation. This entire process is executes in loop. Steps for data collection at nodes level are given below:

```
For (mBs=0; mBs=<5; mBs++)
    If mBs=5;
 then  DRN performs aggregation, send DDN
        Exit;
    Else mBs!=5;
       DRN collects data from BSNs
```

Figure 4.2: Algorithm for Nodes data collection

4.6.2 Data Flow at AUV Level

AUV gathers data from the DDN, and checks that the data is related to emergency event or non-emergency. In non-emergency case (EM != 1), AUV follows forward direction for movement and gathers data from the DDN. Further checks that if condition DDN(i)<=TDDNs (current DDN's number is less or equals to entire amount of DDN), if condition is true (yes) then AUV continuously move forward and gathers data from the DDN; as well as increment the number of current DDN. Else DDN(i) >= TDDNs (current DDN's number is less or equals to entire amount of DDN), then AUV done aggregation and forward data to SN and terminate the process.

```
Initialize i=0 to i=10;
Int Total_DDNs=5;

1.for (i=0; i<= 5; i++)
2.  int a=dist_cacl from DDN(i) to Pr-SN & Nx-SN
3.      int b[i]=a;
4.  AUV collect data from DDN(i)
5. If EM !=1 (non-emergency scenario) then
6.      AUV collect data from DDN(i)
7.      If DDN(i) <= Total_DDNs then
8.              i++;
9.              go to step 1
10.     Else AUV performs aggregation and sends data to SN
11              End
12. Else EM == 1 (emergency scenario)
13.     if  dir != null
14.             AUV performs aggregation and sends data to SN
15.     Else
16.             if dist_cal from  b[i+1] > [bi]
17.                     Set Dir = Backward
18.             Else set Dir = Fwd
19.                     AUV performs aggregation and sends data to SN
20.             End If
21.              i++;
22.     End If
```

Figure 4.3: Algorithm for Data Collection

On the other hand, when emergency event occurs (EM = 1), check both things i.e. distance is calculated or not as well as direction is either null or null. If distance is calculated and direction is not null, AUV execute aggregation and forward data to SN. Else distance is not calculated and direction is null, then from current DDN to SN calculate distance. Moreover, check distance of next SN is greater as compare to previous SN, then set backward in direction; AUV do aggregation and forward data to SN. Else if distance of next SN is less as compared to the previous SN, then set forward in direction. So, AUV execute aggregation process then forward data to SN. Algorithm for the data collection at AUV level is given below in Figure 4.2.

Given algorithm is un-like from Zahoors' algorithm given in [20], as well as un-alike than equations which are given in [21] by Jawhar. [20] proposed an algorithm just for node's deployment, but that algorithm is not able to handle emergency event as well as non-emergency scenario. On the other hand, Jawhar proposed equation for the calculation of maximum delay in both cases i.e. emergency case and non-emergency (normal case), speed of AUV, and size of buffer. But proposed algorithm supports emergency events and non-emergency, also gives entire data flow from BSN to NCC.

4.7 Summary

In this section, details of proposed solution is given. Discussed that how to resolved an identified issue. Proposed work is divided into two phases, phase 1 is from gathering data and aggregation from BSN to DDN level. Moreover in phase 2, AUV gathers data and checks condition. Also objectives of this work is explained, that are: energy saving, reduced number of messages, and handling of emergency events more efficiently.

CHAPTER 5

PERFORMANCE EVALUATION

5.1 Overview

In ALSN, AUV visits every node for data gathering, as a result more energy is consumed and more messages are utilized for communication. In EULWSND no emergency scenario is considered. So, when emergency event occurs loss of material, underwater habitat and economy occurs. So, to overcome these issues, scheme is given. This scheme performs better than ALSN and EULWSND in terms of energy consumption, number of messages for communicated. Also performs better in terms of emergency scenario, as well as in normal (non-emergency) scenario.

5.2 Results and Analysis

Simulation is performed in NS2. Also compared results for the delay, energy, communication cost, and delivery ratio. The parameters are used for simulation: d, n, CR, dc and s. Total SNs are used for the entire network coverage are shown by “n”. Distance between any of two consecutive SN is represented by “d”. The distance which is cover by an AUV, when it is passing over the SNs while SNs are in a communication range of one another is shown by “CR”. The data size that is exchanged for the communication between SN and AUV which is in size and shown by “L”. AUV’s are shown as “s”. Results are compared for packet delivery ratio and overhead when the number of nodes deployed in the region are increased. If most nodes in the network exchange information which tends to communication overhead. It is expected that cost of communication is reduced by applying the given scenario due to region and event specific data collection mechanisms with dynamic speed. After that, also compare the results for the impact of buffer size over packet delivery ratio. Impact of increasing buffer size on the improvement of delivery ratio. Next, represent the comparison of AUV speed vs delivery ratio by the help of graph when AUV speed increases then delivery ratio is increased or decreased.

5.3 Comparison of Parameters

In this section different parameters are discussed, which are based on comparison done in current work. These are discussed below under specific heading.

5.3.1 Communication Delay

The given scheme handles the scenario of emergency more effectively as compared to the both EULWSND and ALSN. Also performs better than both of them in respect to the number of the messages and energy consumption patterns. This scheme use less energy compared to [21], our scheme least number of messages are consumed comparatively. In the ALSN more amount of communication messages are used which are a cause of more energy usage. On the other hand in our scheme hierarchical model is used for delivering data gradually from BSN to NCC, so less amount of messages are used for communication. As a result less energy is consumed.

5.3.2 Energy Consumption

This scheme is better in terms of energy consumption than base schemes EULWSND and ALSN, because this work uses a hierarchical model for data traveling.

At each level data aggregation is performed. But in the base scheme EULWSND, AUV visits every node for the gathering of data. So, more energy are consumed.

5.3.3 Number of Messages

In this scheme, less number of messages are used for communication, because at every level data aggregation is performed. As well as AUV just gathers data from DDNs, while in the base scheme ALSN AUV visits every node for gathering of data. So, in base scheme more number of messages are utilized for communication. On the other hand, in this scheme less number of messages are used for communication.

5.3.4 Network Lifetime

In this scheme, as less energy is consumed and as well as less number of messages are used. As less energy is consumed then nodes survive for a longer duration. So network's life is increased.

5.4 Graphs of proposed scheme

In this section composed graphs are shown as well as discussed. Their values, scope, and impact are discusse

5.4.1 Delivery Ratio vs Buffer Size

Figure 5.1 represents a relationship between delivery ratio and buffer size while AUV's speed is constant. Also presents impact of increasing of buffer size and increasing the number of nodes on the delivery ratio. For the buffer size "bs" bs=5, bs=10, bs=15, bs=20, bs=25 and bs=30 then the value of delivery ratio "dr" is dr=7 and 8, dr=8 and 9, dr=10 and 11, dr=12 and 13, dr=14 and 15, dr=15 and 16, and dr=16 and 17 respectively. While the buffer size has a 20 delivery ratio is 12 and 13, results shows that as buffer size increases, delivery ratio increases. Its means that buffer size is directly proportional to delivery ratio. To get a maximum delivery ratio a suitable buffer size is required.

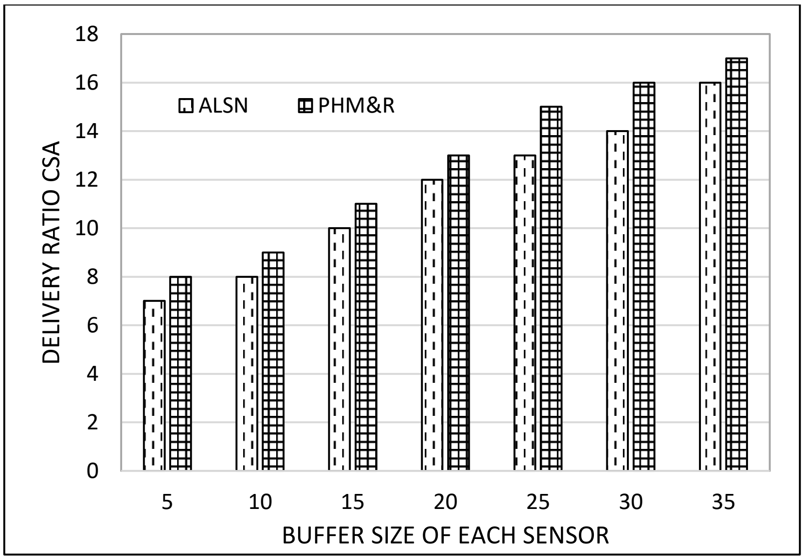

Figure 5.1: Buffer size vs Delivery ratio

Figure 5.2 represents a relationship between delivery ratio and buffer size while AUV's speed is constant. Also presents impact of increasing of buffer size and the number of nodes on the delivery ratio. For the buffer size "bs" in case of ALSN bs=5, bs=10, bs=15, bs=20, bs=25, bs=30 and bs=35 then the value of delivery ratio "dr" is dr=7, dr=8, dr=10, dr=12, dr=14, dr=15, and dr=16 respectively. While the buffer size is 20 delivery ratio is 12 and 13, results shows that as buffer size increases then delivery ratio increases. For the buffer size "bs" in case of PHMR bs=5, bs=10, bs=15, bs=20, bs=25, bs=30 and bs=35 then the value of delivery ratio "dr" is dr=8, dr=09, dr=11, dr=13, dr=15, dr=16, and dr=17 respectively. While the buffer size is 20 delivery ratio is 0.13 its means that buffer size is directly proportional to delivery ratio, so as buffer size increases delvery ratio is increases. To get a maximum delivery ratio a suitable buffer size is required.

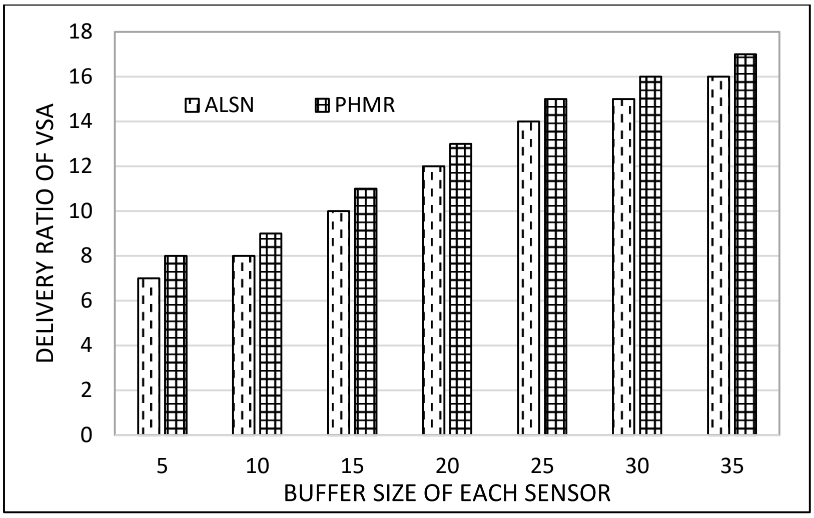

Figure 5.2. Buffer size vs Delivery ratio

5.4.2 Buffer Size vs Average Delay

Figure 5.3 represents a relationship between buffer size and average delay, in case of fixed speed AUV. Also present impact of increasing of buffer size and also increasing the number of nodes on the average delay. The buffer size "bs" have values are bs=5, bs=10, bs=15, bs=20, bs=25, bs= 30, bs=35 and bs=40, then the value of average delay "ad" for ALSN and PHMR is ad=30 and 31, ad=32 and 33, ad=35and 36 ad=37 and 38, ad=37 and 38, ad=38 and 39, ad=39 and 40, ad=40 and 41 and ad=40 and 42 respectively.

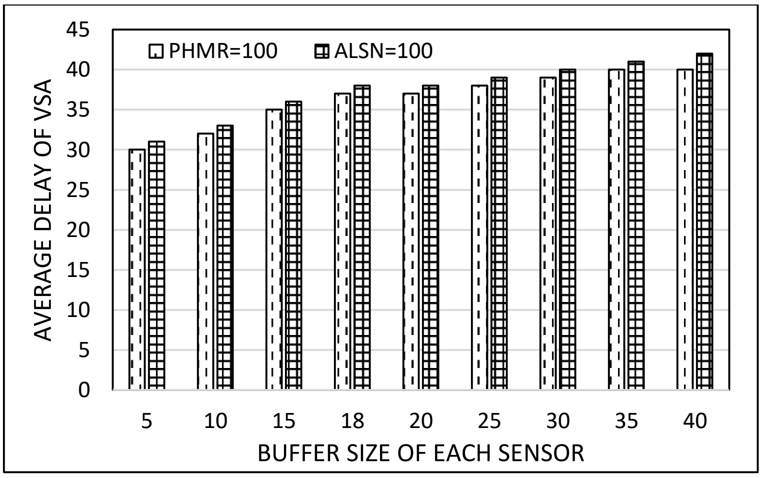

Fig 5.3: Buffer size vs Average delay

Results shows that as increase buffer size also average delay increases. When buffer size increases then average delay increases. Its means this technique is more suitable or give minimum average delay when buffer size is less/least.

Figure 5.4 represents a relationship between buffer size and average delay, in case of dynamic/variable speed AUV. For the buffer size “bs” values are bs=5, bs=10, bs=15, bs=20, bs=25, bs= 30, bs=35 and bs=40, then the value of average delay “ad” for ALSN and PHMR is ad=109 and 111, ad=109 and 110, ad=109 and 110, ad=110and 110, ad=111 and 112, ad=112 and 112, ad=114 and 115, and ad=118and 125 respectively. Results shows that as increase buffer size also average delay increases. When buffer size increases then average delay also increases

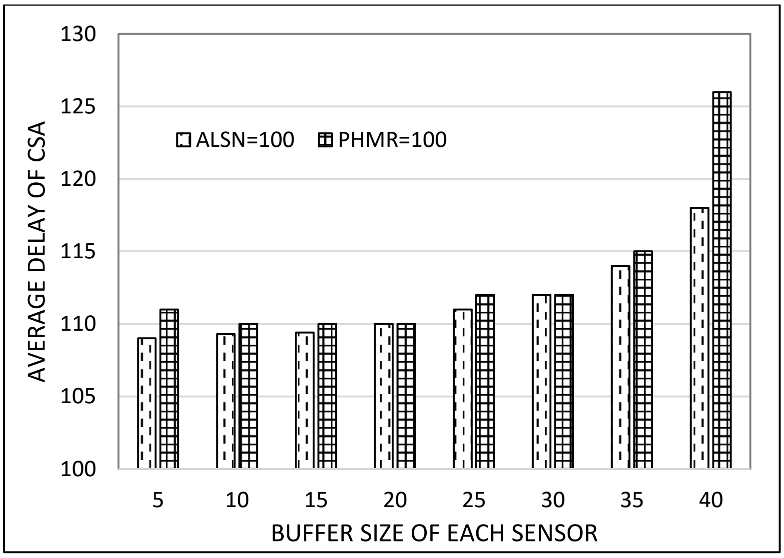

Figure 5.4: Buffer size vs Average delay

5.4.3 AUV Speed vs Delivery Ratio

Figure 5.5 represents a relationship between AUV speed and delivery ratio, in which AUV speed is fixed. Also present impact of increasing AUV speed on the delivery ratio. For the AUV speed “s” s=0.05, 2=0.1, 0.15, 0.2, 0.25, and 0.3 delivery ratio “dr” for the ALSN and PHMR is dr=0 and 0.01, dr=0.01 and 0.02, dr=0.04 and 0.05, dr=0.08 and 0.09, dr=0.13 and 0.14, and dr=0.16 and 0.17 respectively. As increase in AUV speed also delivery speed increases. When AUV speed decreases then delivery ratio increases. Its means this technique is more suitable or give maximum delivery ratio when AUV speed is maximum.

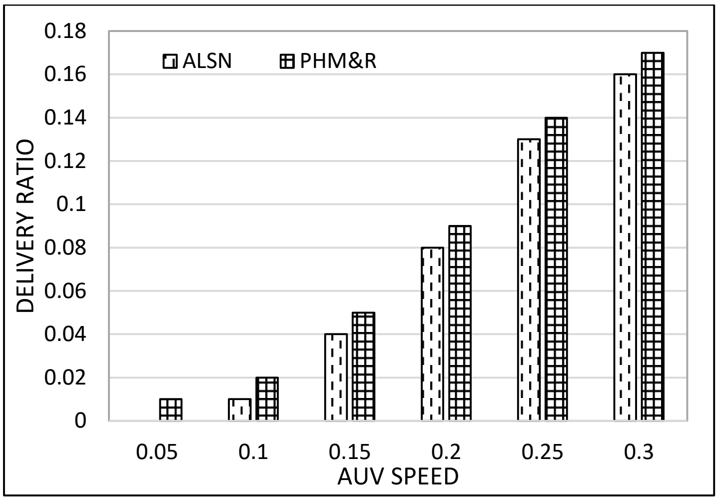

Figure 5.5: AUV speed vs Delivery ratio

Figure 5.6 represents a relationship between AUV speed and delivery ratio, in which AUV speed is variable. Also present impact of increasing AUV speed and also increasing the number of nodes on the delivery ratio. For the number of nodes n=40, n=60, n= 80, and n=100, then the value of delivery ratio is 0.08, 0.13, 0.15, and 0.28 respectively while the AUV speed "s" is s=0.2. Results shows that as increase AUV speed also delivery speed increases.

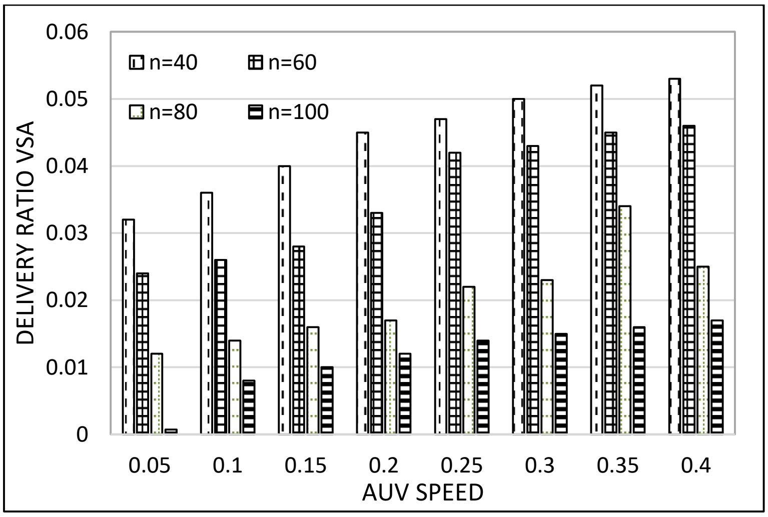

Figure 5.6: AUV speed vs Delivery ratio

When AUV speed increases then delivery ratio increases. Its means this technique is more suitable or give maximum delivery ratio when s is maximum.

5.4.4 AUV Speed vs Number of Messages

Figure 5.7 present a relationship between number of messages during data collection and AUV speed. Also present impact of increasing AUV speed as well as constant AUV speed on the number of messages during data collection. So, as speed of AUV increased then number of messages, this is according to expectations as more number of messages are reached at destination.

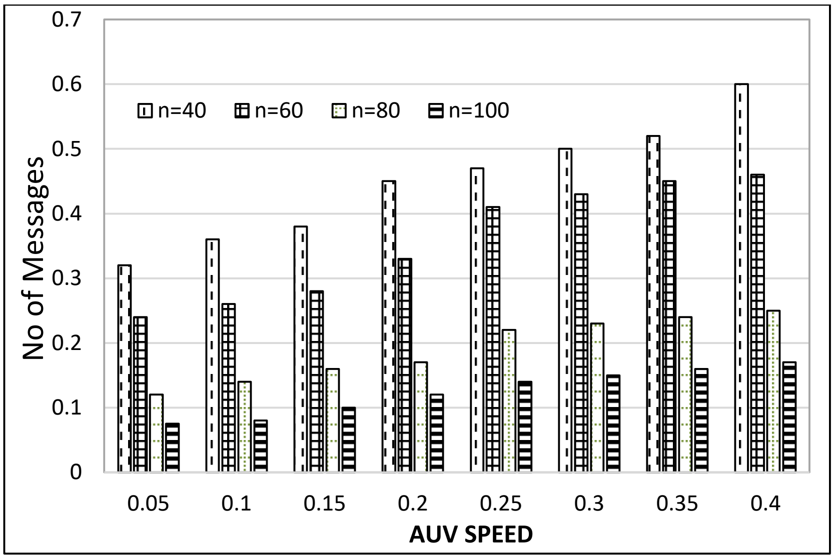

Figure 5.7: AUV speed vs Number of messages

5.4.5 Number of Messages vs Energy

In this work comparison is performed for energy consumption of PHMR with EULWSND with respect to the no of messages, x-axis presents no of messages while y-axis presents energy. When BSN's are ten, then AUV forwards ten messages in EULWSND as shown by value "10" with consuming "7μJ" energy, while AUV share one message to SN in PHMR as value "1" with consuming "0.7μJ" energy. Less number of messages, less data are utilized for communication in PHMR. So less energy is consumed.

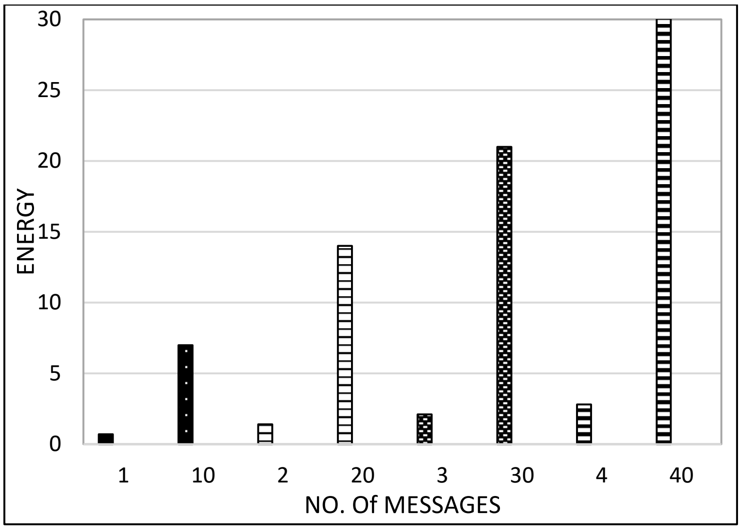

Figure 5.8: Number of messages Vs Energy

5.4.6 Number of Messages vs Delay

Also comparison is performed for no. of messages used in PHMR with EULWSND and ALSN. In graph x-axis presents the no of messages while y-axis presents delay. When no. of messages "m" is 20, then ALSN have delay value is 20 and EULWSND have 3 while PHMR have 2. Values shows that ALSN have "10x" higher delay than PHMR, and EULWSND have "6.7x" higher delay. So PHMR performs better than both base schemes

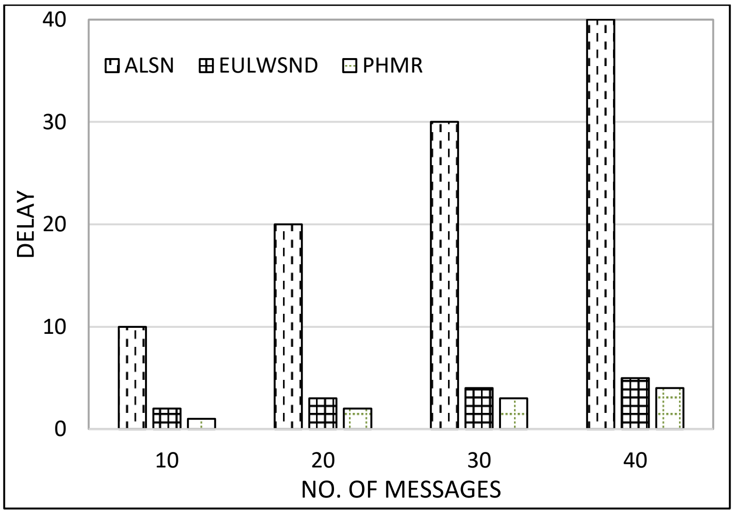

Figure 5.9: Number of messages Vs Delay

5.4.7 AUV's Speed vs Delay

As elestrated when AUV's speed increases then delay is decreases. When AUV's speed is "0.1" then ALSN have delay vallue are is 0.11, 0.06, 0.03, and 0.015 then corresponding EULWSND have delay values are 0.03, 0.015, 0.007 and 0.037; and PHMR have delay values are 0.02, 0.01, 0.005 and 0.002 correspondance to the ALSN's values. It shows that presented scheme have least delay than both the base schemes.

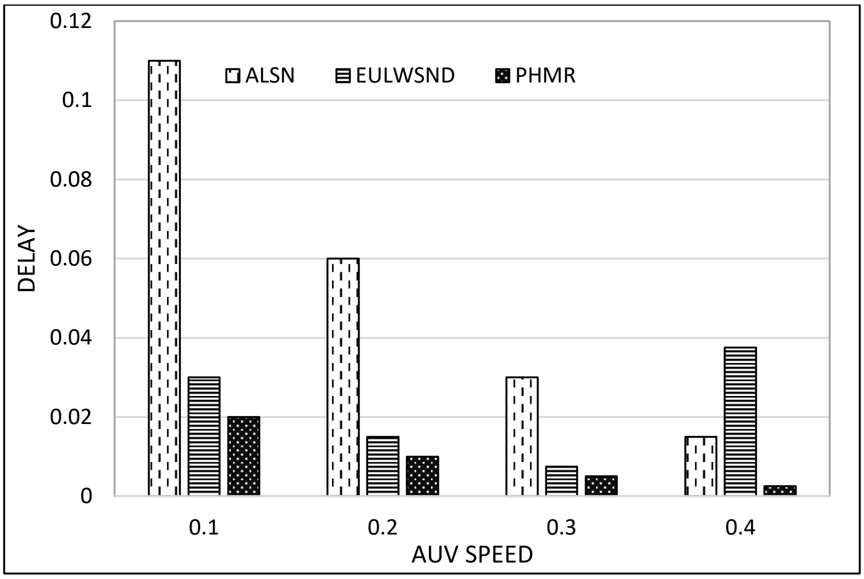

Figure 5.10: Number of messages Vs Delay

5.5 Summary

In this chapter results and analysis, and comparison with based scheme are discussed. This scheme is compared on the basis of communication delay, energy consumption and number of messages. This scheme performs better than base schemes in terms of communication delay, energy consumption, and also number of messages. Also composed graphs their trends and impact are discussed. Graphs shows that presented scheme is better than base schemes.

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 Overview

Main aim of this work is to handle emergency events in underwater pipeline more efficiently than the based schemes. As soon as possible reporting of emergency events in minimum time. Also both emergency and normal (non-emergency) are considered and both cases are handled more efficiently than based schemes.

6.2 Summary of contribution

In this section contributions are given, that are in this work which used less number of messages for communication, also consume less energy, and as well reporting of emergency events done in less time that have a base scheme. Contributions are: 1) Less number of messages for communication: For communication less number of messages are used. Hierarchical model is followed to reduce the amount of messages. Also perform aggregation on steps of hierarchy to reduce the amount of messages. 2) Energy consumption: By followed a hierarchical model, reduce the amount of energy utilization. Also in based scheme, AUV visits every sensor node as a result more energy is consumed, but in this scenario AUV just collects data from DDNs. So, less amount of energy is consumed. 3) Report of emergency event in possibly lesser time: When emergency event occurs then as soon as possible AUV send its data to a sink node. To reduce the amount of loss of material, economy, underwater habitat.

6.3 Conclusion

Author noticed the issues in some previous techniques and proposed a solution to resolve these issues. Also compared given scheme with that and proposed scheme performing better than both schemes in terms of energy cost, number of messages and emergency situation handling. In this scheme, for data collection from DDN uses AUV, DDNs collects data from the below level nodes as given in proposed hierarchical model. For transmission of the data to SS, AUV decides which SS is nearer, either back one or the forward one, then moves towards that specific nearest SS for sending of the data. This scheme is suitable for both cases, delay tolerant as well as non-delay tolerant. In case of constant speed AUV it handles delay tolerant data, and in the case of dynamic speed AUV it deals with non-delay tolerant data. It uses multi-hop communication to reduce the number of messages as well as amount of energy usage than the ALSN. As in ALSN, AUV visits every BSN for data collection as a result more number of messages are used and also more energy is consumed. This scheme handles both emergency scenario and normal scenario in a very efficient manner. Also handles emergency cases much better than ALSN, importance of this scenario that it is more efficient because if any emergency is occurred and action could not be taken within a minimum amount of time it results in a loss of economy, environment and underwater habitat. Also compare current scheme with EULWSND, ALSN and results show that our scheme performs better. Our main focus is to manage emergency scenario within a minimum time interval reporting of emergency to NCC. So action will be taken within limited amount of time to reduced loss of material, economy and underwater habitat.

6.4 Future Work

In the future, number of nodes as well as simulation areas will be more increased. This model will be deployed for the larger pipeline. Also if any low level node (LLN) that have equal distance from two higher level nodes (HLN), then LLN choses that HLN which has more energy. In case of sensitive data (military, intelligence) use strong security mechanism for communication.

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