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RSSI Based Oil and Gas Pipeline Controlling and Alert System

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ABSTRACT: Wireless sensor networks have extensively been utilized over the years for ambient data collection from diverse structural deployments including mesh, ad hoc, and hierarchical layouts. Several other applications of sensor networks may involve placing the nodes in a linear topology, constituting a special class of networks called linear sensor networks. In a densely deployed linear network case, issues related to optimal resource allocation and networking may persist because the standard sensor network protocols attempt to manage the network as a mesh or ad hoc infrastructure. Issues like recovering from holes where a node cannot reach another node in either side or policies to establish a route for data dissemination need to be intelligently solved for linear sensor networks. To solve such issues, we propose a linear sensor network deployment application for oil and gas pipeline using a custom sensor board accompanied with algorithms to solve network creation, leak interrupt detection, and routing of high-priority messages with reliability while keeping network alive at all times. The proposed system provides all the features of leakage detection, localization, parameter sensing, and actuation, while operating at low energy, high data reliability, and low latencies, while comparative results prove the efficacy of the system.

KEYWORDS: Coverage, leak detection, routing, wireless sensor network, ZigBee.

I. INTRODUCTION

Advances in wireless communication protocols and embedded design have led to the emergence of low-powered miniature-sized multifunctional sensor nodes for wireless sensor networks (WSNs) operating in fields ranging from battlefield and environment monitoring to health and entertainment. The sensor nodes are capable of detecting environment parameters within the sensing range and routing data over multihops to nodes within its communication range. Sensor nodes usually work in collaboration to monitor inaccessible areas.WSNcoverage requirements may allow uniform node layout or necessitate denser deployment for higher surveillance. Mostly, the coverage requirement can be approximated with a finite set of points for regular structures. After deployment, the network reliability depends upon several parameters including connectivity, data routing delay, and sensor event detection accuracy. WSN deployment involves several decision parameters, e.g., the number of sensor nodes deployed and the sensing rate for the node failure to be easily detected, while nodes' activity lasting for longer periods. Node deployment location and internode distances also influence energy usage.

Data exchange frequency needs to be wisely scheduled to improve network lifetime by even distribution of energy load. Network lifetime is defined as the time period until all active sensor nodes fail to provide connectivity or are exhausted. Monitoring of oil and gas pipeline similar to bridges and tunnels not only proves challenging due to extensive linear span but also due to critical fluid condition sensing requirements. Inaccuracies in sensor measurement from a single node can propagate over the network causing distortion in measurements from other sensors when aggregated. Quality of service in linear WSN mandates intelligent data exchange method coupled with node sleep and activity cycles. The quality of link defined by received signal strength indicator (RSSI) is a major parameter for network connectivity. For acceptable QoS levels, critical information must not be delayed nor lost beyond a certain bound. Further, network topology needs to be designed keeping in view data load at critical points and a routing mechanism where conventional routing parameters including hop distance, time stamps, and channel quality can be

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included. Network reliability, fault tolerance, and delay minimization are in many cases coupled with routing decision itself. Linear WSNs (LWSNs) provide a special case where multi-hop communication over long distances results in increase of data delivery time.

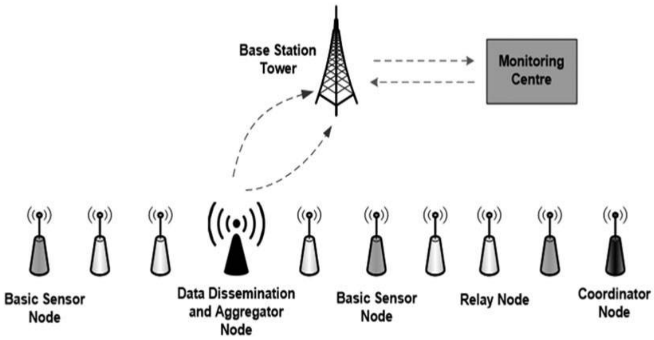

Fig.1 Example of a linear infrastructure monitoring with data dissemination relay and basic sensor node

LWSNs may be simplistic in topology but the decision of routing and deployment of nodes to conserve resources is not simple. Such network problems have been a research focus recently considering several sensor applications. A summary of detailed hierarchical and topological classification of linear sensor networks is provided in earlier systems. The work by Mohamed et al. aim at providing a theoretical model to evaluate LWSN coverage with existence of node faults and varying maintenance periods thus supplicating design of LWSN with given specification. Some interesting recent applications of LWSN include topology discovery as a train backbone network. Major issue of wireless channel impairment is solved by use of a novel topology discovery or train inauguration scheme. Jawhar et al. propose a data communication scheme in LWSN using unmanned aerial vehicles (UAV). The network performance is measured considering parameters likeUAV speed, data rate, end-to-end delay, node buffer size, and number of relays in each segment. Lin et al. have proposed a WSN application for monitoring power transmission lines using a clustering algorithm to balance energy consumption and leverage hybrid media access control (MAC).

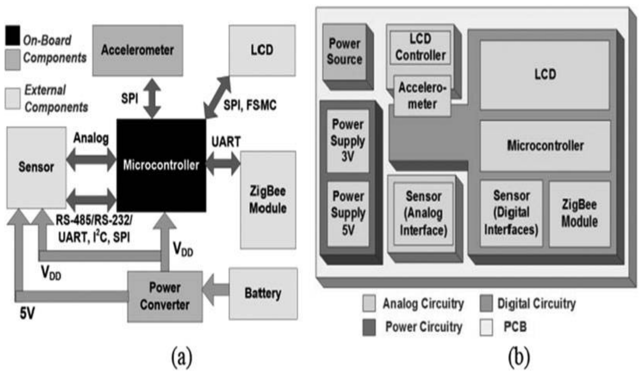

Fig. 2. SimpliMote. (a) Scheme. (b) Implementation

The use of cross layer protocols for demanding real-world applications, however, makes the system complex to implement and less responsive. Akbar et al., in their contribution for LWSNs, propose mobile sinks, autonomous vehicles, and courier nodes that work underwater in a 3-D linear formation that minimizes energy consumption as well as accurately computing required routing information. Such a 3-D linear system is though accurate in routing, yet too complex for real-time sensing and response implementation in mission critical applications.

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Similarly, Jawhar et al. in past systems have proposed a ferrybased LWSN where the data collected are assumed to be delay tolerant. A moving vehicle, robot, or any other mobile node can move back and forth along the linear network while collecting data from basic nodes. Four different movement patterns of the nodes are presented, but the assumption of delay-tolerant data does not make it feasible for a LWSN system that is deployed for monitoring oil and gas pipeline condition. The sensor node hardware platform plays an important role in the performance of the network. A multimedia sensor application requires comparatively more powerful microcontroller than a simpler application like room temperature monitoring.

A survey of the most popular WSN platforms is provided in earlier systems. While the sensing plane of a platform focuses more on sensing issues and communication problems, a more flexible platform can provide cross layer intelligence to handle more complex tasks and multiple sensing scenarios. Monitoring of oil and gas pipelines poses a challenge in terms of sensitivity of the fluid dynamics as well as timely delivery of critical information. In this system, we provide a detailed system level description of a specialized platform with algorithms that supplement the ZigBee and similar protocols like WirelessHART and 6LowPAN to handle the oil and gas pipeline monitoring concerns. This system is an in-depth extension of the initial limited work presented in earlier stages. An algorithm for network setup and control and sensing data exchange is provided in LWSN scenario that supplements the ZigBee protocol.

A number of software and hardware limitations which are inherent in commercial-off-the-shelf (COTS) and standard WSN protocol routines have been taken into account in the development of our WSN platform which we call SimpliMote. The basic routing approaches for WSN including ad hoc on demand distance vector, source routing, and many-to-one routing utilize extra messages that if avoided in linear network configuration can save time, energy, and data size. The approach presented in this system works with the basic WSN nodes including coordinator, router, and sensor nodes. The network setup and joining and leaving of nodes are done by application messaging framework around the coordinator. A disadvantage of the ZigBee discovery mechanism is that for each broadcast transmission, the ZigBee stack must reserve buffer space for a copy of the data packet for retransmission; hence, broadcast messages need be used sparingly for larger packet sizes. Also, broadcast messages need to be controlled over the network and unicast massages used instead which further require the addresses be intelligently projected. Each unicast transmission supports up to 84 bytes of radio frequency payload which is further limited when using security features. Fragmentation is supported in unicast only where the transmitted frame of a maximum 255 bytes data is broken into multiple transmissions and reassembled on the receiving side.

This fragmentation is a direct result of buffer limitation of the hardware platform. Further, due to memory constraints, only one fragment is supported at a time by the Zig-Bee firmware. For reliability, ZigBee sends acknowledgment packets at both the MAC and application layer which in some low-priority messages might not be required at all. Such software and hardware limitations have been taken into account in the development of SimpliMote. The novelty of our solution include method to effectively detect sensing events by removing noise on custom nodes, routing the information while labeling it into different priorities and keeping the network alive at all times with provision of real time remote monitoring. Comparison results against COTS solution prove the efficacy and necessity of our proposed system.

II. PAST SYSTEM – A SUMMARY

In the past system there is no specific application for oil and gas pipeline holes detection. Using a computerized signal processing scheme, the leakages in pipelines are identified, which is not accurate and correct. Reliability is less in the past system, because of its poor performance and alert cases. The existing system contains several disadvantages, some of them are listed below: (a) Using Computerized Signal processing Scheme for Defect Detection, (b) Probabilistic Results not producing accurate defect conditions, (c) Less Reliability and (d) Performance is too low.

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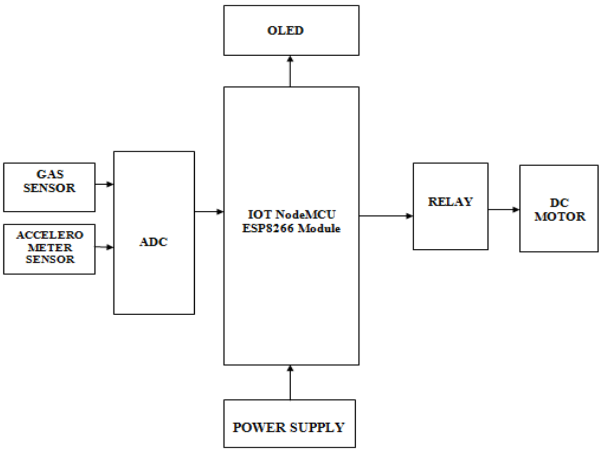

Fig.3 Block Diagram –Transmitter Unit

Proposed System Summary

In the proposed system, to overcome the above mentioned issues, we proposed a linear deployment model for oil and gas pipeline defect detection using custom sensors. The Sensor board named SimpliMote accompanied and guarantees these sensors to detect leakages, high-priority messages with reliability. This system provides all the features of leakage detection, localization, parameter sensing, and actuation, while operating at low energy, high data reliability, and low latencies, while comparative results prove the efficacy of the system. The proposed system contains several advantages, some of them are listed below: (a) Using SimpliMote suggested Sensor schemes to detect defects in pipelines, (b) Accurate detection of defect conditions in gas and oil pipelines, (c) High Reliability and (d) Good in Performance and Speed.

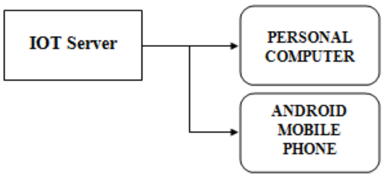

Fig.4 Block Diagram – Receiver Unit

III. LITERATURE SURVEY

In the year of 2013, the authors "I. Jawhar and N. Mohamed" proposed a paper titled “A hierarchical and topological classification of linear sensor networks", in that they described such as: Considerable advancements in the technology of wireless sensor networks (WSNs) are taking place due to smaller, and more efficient electronic devices which are capable of increased processing power, and communication capabilities. In addition, the cost of such devices is constantly decreasing, which makes it possible to employ large quantities of networked sensors in numerous commercial, environmental, military and health care applications. A lot of these applications involve lining up the sensor nodes in a linear structure giving rise to a new class of WSNs, which is defined in this work as Linear Sensor Networks (LSNs). This paper identifies some of the applications that might use such networks and offers a classification of the different types of LSNs from a topological and hierarchical points of view. Finally, a motivation for designing specialized protocols that take advantage of the linearity of such networks in order to increase reliability, efficiency, energy savings, and network lifetime is offered along with the new research issues, challenges and opportunities that exist in this field.

In the year of 2013, the authors "N. Mohamed, J. A. Jaroodi, I. Jawhar, and A. Eid" proposed a paper titled “Reliability analysis of linear wireless sensor networks", in that they described such as: Linear Wireless Sensor

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networks (LSN) are used to monitor long linear critical structures such as pipelines, rivers, railroads, international borders, and high power transmission cables. Due to the importance of these structures, the LSN must be designed with high reliability considerations. However, one of the main challenges of LSN design is the connection reliability among the nodes. Unlike in Wireless Sensor Networks (WSN) in which sinks can be reached through multiple existing paths which can be utilized to enhance the reliability, very few alternate paths are usually available in LSNs. Faults in a few contiguous nodes in a LSN may cause the creation of holes. The nodes on either side of a hole may not be able to reach each other which will result in dividing the network into multiple disconnected segments. As a result, sensor nodes that are located between holes may not be able to deliver their sensed information which negatively affects the network's sensing coverage. In this paper, we develop an analytical model to provide reliability analysis for LSNs. We use this model to demonstrate two design applications. The first application is to use the model to create periodic maintenance schedules for existing LSNs while the second application is to use the model for new LSN designs and to compare different possible alternative designs.

In the year of 2015, the authors "I. Jawhar, N. Mohamed, J. Al-Jaroodi, and S. Zhang" proposed a paper titled "Data communication in linear wireless sensor networks using unmanned aerial vehicles", in that they described such as: the wireless sensor network (WSN) technology have been evolving very quickly in recent years. Sensors are constantly increasing in sensing, processing, storage, and communication capabilities. In many WSNs that are used in environmental, commercial and military applications, the sensors are lined up linearly due to the linear nature of the structure or area that is being monitored making a special class of these networks; We defined these in a previous paper as Linear Sensor Networks (LSNs), and provided a classification of the different types of LSNs. A pure multihop approach to route the data all the way along the linear network (e.g. oil, gas and water pipeline monitoring, border monitoring, road-side monitoring, etc.), which can extend for hundreds or even thousands of kilometers can be very costly from an energy dissipation point of view. In order to significantly reduce the energy consumption used in data transmission and extend the network lifetime, we present a framework for monitoring linear infrastructures using LSNs where data collection and transmission is done using UAVs. The system defines four types of nodes, which include: sensor nodes (SNs), relay nodes (RNs), UAVs, and sinks. The SNs use a classic WSN multihop routing approach to transmit their data to the nearest RN, which acts as a cluster head for its surrounding SNs. A UAV moves back and forth along the linear network and transports the data that is collected by the RNs to the sinks located at both ends of the LSN. We name this network architecture a UAV-based LSN (ULSN). In addition, three different UAV movement approaches are presented, simulated, and analyzed in order to measure the system performance under various network conditions.

IV. EXPERIMENTAL RESULTS

The following figure shows the Simulation view of the proposed system.

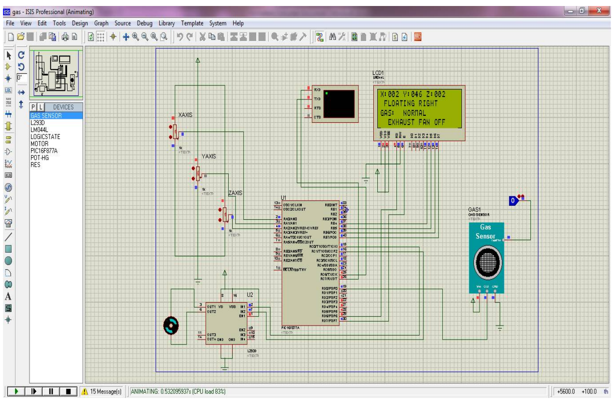

Fig.5 Simulation Design of the proposed System

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V. CONCLUSION

In this system we designed a application for oil and gas pipeline defect detection using custom sensors, which are approved by Sensor board named SimpliMote. The proposed defect detection and leakage detection approach is twice more energy preserving, reliable, and timely when implemented on mission intensive SimpliMote platform as compared to the generic Arduino node. More importantly, the embedded application includes features including time synchronization and software interrupts necessary for handling smooth data flow and responding to critical situations.

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