Tracking Mobile Targets through WirelessHART

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Abstract: ***WirelessHART has emerged as strong alternative to other WSN. In this paper we are going to present design for tracking mobile targets through WirelessHART in process industries. This system can give real time data for gas leakage areas also it will track location of worker moving in that particular area and alert him from hidden danger. Field devices are installed in factory and location of field devices is stored in network manager when there is gas leakage and worker carrying handheld device moving in leakage area then network manager will determine location of worker by RSSI based localization method and alert will be given to worker and his life can be saved***

Keywords: Wireless sensor networks, WirelessHART, Localization, MICROCHIP's MRF24J40MB, RSSI

1. Introduction

In large refineries and petrochemical industries there is possibility of hazardous gas or chemical leakage. In this condition small negligence may cause heavy human loss and economical loss. It is more important to know location of field engineer or worker, so that his life can be saved by alerting him about hidden danger [2]. With advancement in wireless sensor networks there is huge necessity to develop such a safety system which would be reliable and will offer guaranteed performance in such harsh environment. With WirelessHART we can design such system.

In design of this system we will have two types devices mainly stationary devices i.e. field devices and mobile devices i.e. worker carrying handheld device. Location of field devices is already stored in network manager database. Network manager will maintain neighbour table. Now when worker moves in such areas where chemical or gas leakage has occurred then at that time signal strength of workers handheld device will be calculated and neighbour table of network manager will be automatically refreshed and when signal strength of field device and handheld device are matched at that time workers location is determined and alert will be given to worker by activating buzzer.

2. Localization

Localization in wireless sensor network has grabbed attention of many researchers recently. The real-time knowledge of the location of personnel, assets, and portable instruments can increase management efficiency. Localization refers to the process of obtaining location information on a node with respect to a set of known reference positions. GPS, infrared [4] are some techniques used for localization but GPS fails in indoor environment because GPS and infrared signals cannot go through wall and other obstacles and power consumption is also more in such devices. There are various distance indication methods are available[4] such as RSSI(Received signal strength indication), TDOA(Time difference of arrival) and AOA(Angle of arrival) out of which TDOA and AOA cannot be used be because they suffers from line of sight problem and requires special hardware. So we will make use of RSSI method while designing our application for use of RSSI we do not require any special hardware and it can be implemented via software also. From experiments it is found that with increase in distance error in RSSI measurement increases[7].Another method for localization is to divide area in to number of regions and then locate workers location if he is in that particular region.

3. WirelessHART Protocol

The HART [1] (Highway Addressable Remote Transducer) Protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring system. Most automation networks in process industry are based on traditional 4-20mA analog wiring, wired HART technology plays a critical role because the digital information is simultaneously communicated with the 4-20mA signal. As of version 7, HART also provides IEEE 802.15.4-based wireless mesh network. WirelessHART [2] is a wireless networking standard based on HART that adds wireless flexibility to an existing HART network. WirelessHART is first open wireless communication protocol, it is built on an IEEE 802.15.4 radio platform operating in the license-free 2.4 GHz ISM band. WirelessHART uses OSI model and is based on the PHY layer specified in the IEEE 802.15.4-2006 standard but specifies its own Data-link, Network, Transport, and Application layers.

4. Basic Features of WirelessHART

WirelessHART [2] is an international standard defined by IEC 62591-1 as of march 2010. Figure 1 show it is based on IEEE 802.15.4-2006 DSSS physical layer with a data rate of 250 Kbps and operating frequency of 2.4-2.483 GHz. WirelessHART uses Time Division Multiple Access (TDMA) technology to communicate between network devices. All devices are time synchronized and communicate in pre-scheduled time window which enables collision-free, power-efficient, and cost effective communication. Predefined time slots also enable the Network Manager to create the optimum network for any application without user interference.

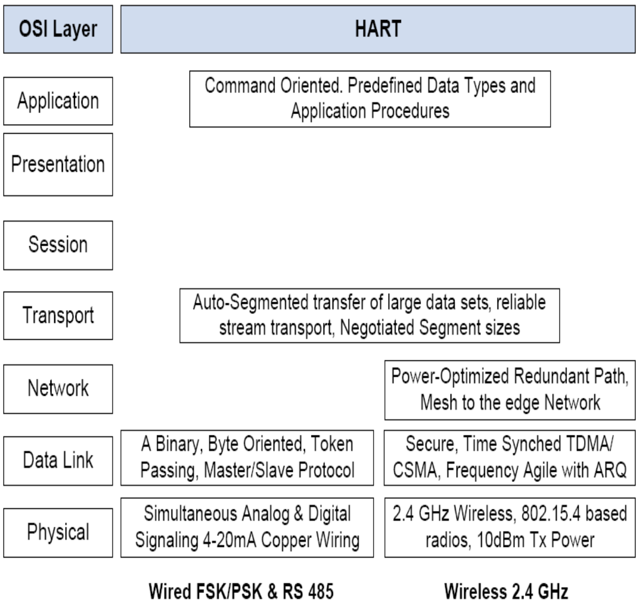

Figure 1: WirelessHART Architecture

Like other technologies that use the 2.4GHz band, WirelessHART could suffer with interference from several other sources. To tackle this problem WirelessHART uses FHSS technique i.e. "hops" across the 16 channels between 11 to 26 defined by the IEEE 802.15.4 radio standard. The Data Link Layer (DLL) provides mechanisms for time synchronisation and transmission between neighbours. All WirelessHART devices have routing capability, as there are no reduced function devices (RFD) like in ZigBee [3]. Since devices can be treated equally in terms of networking capability, installation, and expansion of a WirelessHART, network becomes easy when interference or other obstacles interrupt a communication path, the network immediately and automatically reroutes transmission to other path and because WirelessHART uses a path optimized, redundant mesh topology this benefits the complete network.

Automatic clear-channel assessment (CCA) before each transmission and channel "blacklisting" can also be used to avoid specific areas of interference and minimize interference to others with help of blacklisting feature which is not available in ZigBee. Channels which are affected by consistent interferences could be put in the black list and can be disabled.

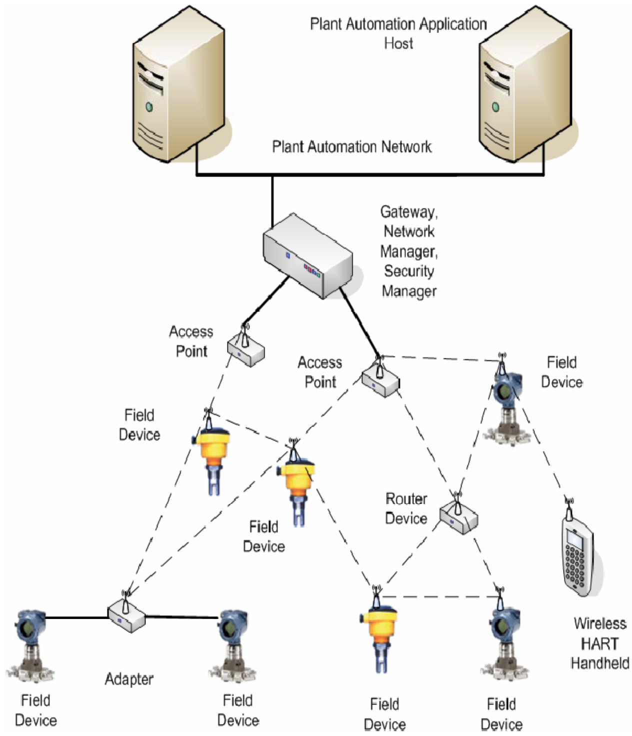

Figure 2: WirelessHART Network Components

Figure 2 shows the different Network device types that comprise a WirelessHART network.

a) **Network Manager:** It is responsible for the overall management, scheduling, and optimization of the WirelessHART network. It provides mechanisms for devices joining and leaving the network. Network manager is responsible for collecting and Maintaining diagnostics and overall health of the network and reporting these diagnostics to the host application. There is only one active network manager for whole network.

b) **Field Device:** These are devices that are connected to the process or to the plant equipment. Router is a special kind of WFD that does not interfere with the process. Gateway Manager: Enables communication between host applications and WFDs in the WirelessHART network.

c) **Handheld Device:** Supports direct access to adjacent WirelessHART field devices.

Security: WirelessHART gives hop-to-hop security measures through encryption and message authentication on the Network and Data-link layers. WirelessHART Utilizes AES-128 block ciphers with symmetric keys for the message authentication and encryption. WirelessHART defines Network, session and join keys.

5. Methodology

In WirelessHART even though various commands are specified already but no command has been specified for location determination. User can describe its own commands at application layer. So this is the challenging part when we think about designing localization application. Our Solution is as follows:

- Firstly signal strength of field devices is stored in database of network manager. Network manager maintains neighbour table which gets updated or refreshed after certain time and which can be set by network manager
- Locating a worker with mobile device is done by the network manager using fingerprinting method [5].Since neighbour health reports are sent periodically to the network manager. So when there is chemical leak or gas leakage occur and worker carrying handheld device moves near to leakage area at that time neighbour table will get refreshed.
- Signal strengths from field device as well as mobile device will be matched by network manager using RSSI and based upon computation he will discard untrustworthy pairs determine location of handheld device whose difference with field device is minimum.

6. Implementation

Hardware Platform: We are using MICROCHIP's MRF24J40MB, PIC18F4620, and MQ-135 CO2 gas sensor.

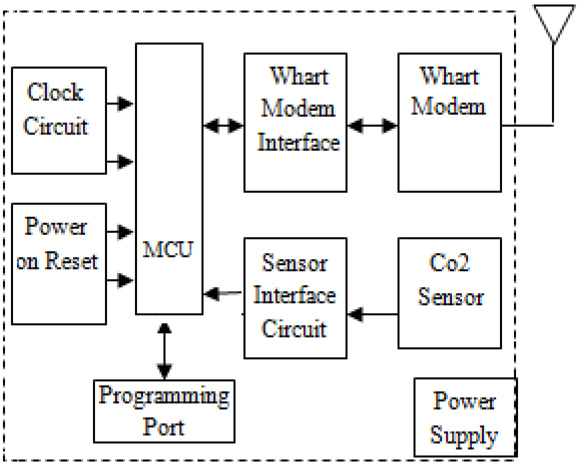

Figure 3: Block Diagram for implementation

MICROCHIP's MRF24J40MB, module provides WirelessHART compatibility, excellent communications reliability and long battery life in a wide range of industrial automation applications. The MICROCHIP's MRF24J40MB, employs dynamic network optimization and intelligent routing to and deterministic power management. MICROCHIP's MRF24J40MB, is tailored for use in battery, energy savaging and loop powered devices for applications that demand robust wireless network reliability. MQ-135 sensor used will be a stationary device. And worker will carry handheld device which comprised of MICROCHIP's MRF24J40MB, transceiver module and PIC controller will be interfaced with each other. When worker carrying this handheld device move in leakage area his location will be tracked as explained in methodology.

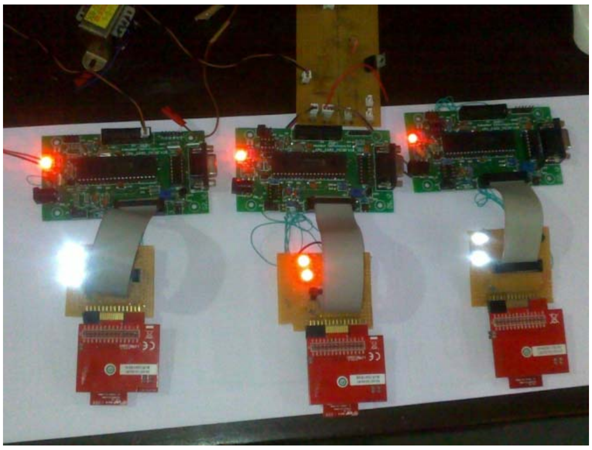

Figure 4: Transceiver Module

In our solution, we followed the suggestion in RADAR [6] mathematical model of indoor signal propagation.

P(d)[dbm] = P(d0)[dbm] -10nlog(d/d0)

Where n is the rate at which the path loss increases with distance, P(d0) is the signal power at certain reference distance d0 and d is the distance.
Experimental Evaluation

We evaluate location application under following two environments

Case A: Indoor environment without obstacles

We have taken area of 4m*10m.In this case we have taken care that there is line of sight connection between pairs of devices. For all scenarios we have assumed p (d0) = 0dbm and d0=1m.
We got, n=9.01

Fig1: Max, Min, Average and Median Values

	Max	Min	Average	Median
Error(m)	7.5	1.2	3.38	2.38

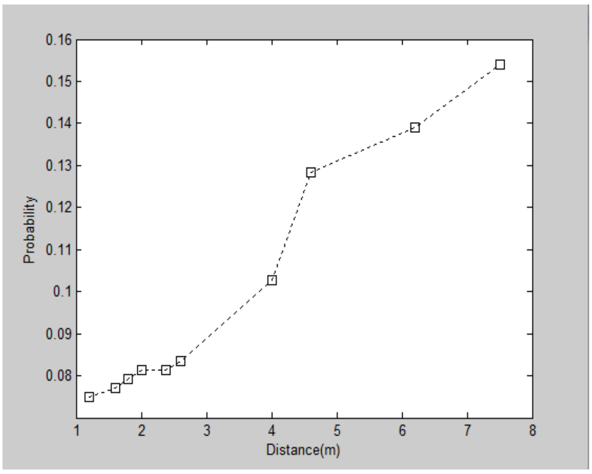

Figure 5: Plot for distance (m) vs. Probability

We have used Matlab to plot our results and results are very promising.

Case B: Outdoor Parking Area

We have performed our experiment in 6m*35m area. We assumed that there is line of sight connection between pairs of devices. As our nodes are battery powered there was no issue while taking long distance measurements.

We got, n=5.84

Figure 1: Max, Min, Average and Median Values

	Max	Min	Average	median
Error(m)	31.5	3	10.21	8.8

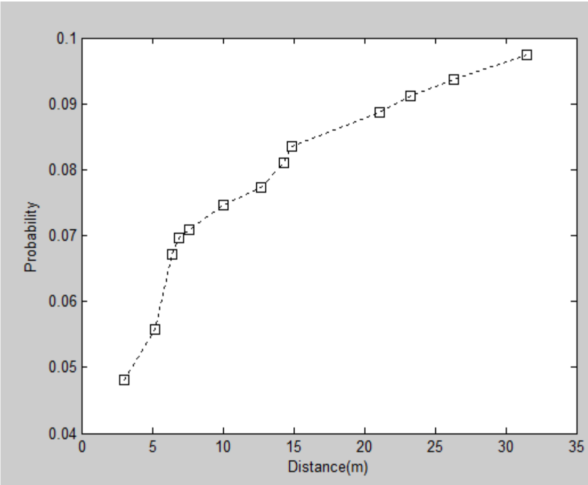

Figure 6: Plot for distance (m) vs. Probability

7. Discussion and Future Work

In this paper, we have designed, implemented and evaluated a localization method on WirelessHART. Our implementation is software-based as well as hardware based thus it is applicable to all WirelessHART networks. It depends upon the received signal strength indication method to estimate distance. We have evaluated our solution is in different test scenarios and results are very promising which is good enough for industrial use. With the widespread adoption of the WirelessHART standard, our work will be increasingly relevant and important in practice. We can find a better radio propagation model so that results will be more accurate. We can also implement blacklisting feature available in WirelessHART so that untrustworthy signal pairs can be eliminated also timing requirement is very important. Furthermore, since the handheld device is suppose to be carried by a worker, previous records can be used for predication. Secondly, our localization algorithm is still introductory. Our application can run on a powerful desktop computer, computational complexity is not an issue. Lastly as WirelessHART is specially designed for industrial use timing requirement is very important

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Ukarande Vaibhav Vishwas received his B.E. degree in electronics and telecommunication from Pune university, Maharashtra, India in 2011.Presently he is pursuing M.E. in electronics from JNEC, Maharashtra, India. He works at MGM's institute as a Lecturer.

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