ISSN No: 2348-4845
International Journal & Magazine of Engineering,
Technology, Management and Research
A Peer Reviewed Open Access International Journal

A Cooperative Wireless Network for tight closed loop applications in Critical Oil/Gas Industry.

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Abstract: ***Wireless Telemetry is the highly automated communications process by which measurements are made and other data collected at remote or inaccessible points and transmitted to receiving equipment for monitoring. In Oil and Gas Industry Telemetry is used to transmit drilling mechanics and formation evaluation information uphole, in real time, as a well is drilled. These services are known as Measurement while drilling and Logging while drilling. Schlumberger's Pulse technology is an example of this. Tools like SlimPulse, PowerPulse, TeleScope, etc. use this methodology to send information acquired thousands of feet below ground, while drilling, uphole to the surface sensors and the demodulation software. The pressure wave (sana) is translated into useful information after DSP and noise filters. This information is used for Formation evaluation, Drilling Optimization, and Geosteering. But Wireless networks are inherently unreliable. This unreliability depends critically on the propagation environment of the radio-links as the layout of scattering objects (pipes and metallic structures) influences the strength and the fluctuations of the received signal power. The development of next generation critical process control systems using the wireless technology calls for the design of advanced network architectures. Here we use level sensor for continuously monitor the oil in storage tanks on the other hand we monitor any gas leak in gas storage tanks using gas sensors .hence up to n no's networks can established using zigbee technology which in turn supports WSNs. The installation of wireless control networks in oil&gas refinery plants is expected to give significant cost/logistic savings in several applications.***

Keywords: ***Wireless sensor network, Oil and gas Industry, Unreliability, Link Layer, Co-Operative Network, Telemetry, Signal strength, Zigbee.***

Introduction:

Although the term Telemetry commonly refers to wireless data transfer mechanisms (e.g., using radio, ultrasonic, or infrared systems), it also encompasses data transferred over other media such as a telephone or computer network, optical link or other wired communications like phase line carriers. Many modern telemetry systems take advantage of the low cost and ubiquity of GSM networks by using SMS to receive and transmit telemetry data.

The increasing demand of oil and gas supplies frequently requires the design and execution of very large production and processing plants over remote locations with harsh environmental conditions and challenging logistics. The adoption of cabling to fully interconnect machines and monitor/control large number of processes is becoming unfeasible due to the high fluctuations of installed industrial wiring costs. The opportunity to replace cabling by deploying a wireless sensor network (WSN) is now becoming of strategic interest for most oil contractor projects. The installation of wireless sensors may give significant cost savings for a variety of typical plants such as revamping/expansions of existing facilities, storage tanks, utilities like water treatment, interconnecting lines, manifolds, high stacks, etc ... In addition, the full plant coverage with WiFi (or) WSN opens the door to many new

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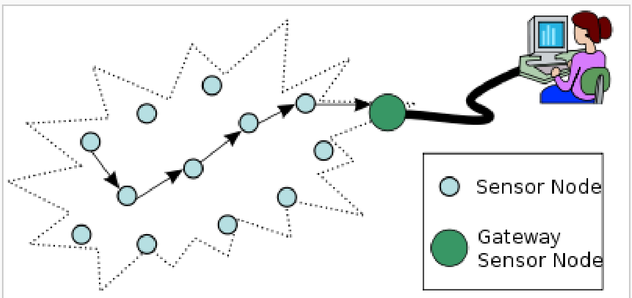
applications which are going to be requested by the end users in the near future.here we deployed zigbee based WSN is less expensive and cost effective when compared with WIFI.

Wireless Sensor Networks:

The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.



Typical multi-hop wireless sensor network architecture

Nowadays, wireless sensor networks (WSNs) are increasingly used in critical applications within several fields including military, medical and industrial sectors. Given the sensitivity of these applications, sophisticated security services are required. Key management is a corner stone for many security services such as confidentiality and authentication which are required to secure communications in WSNs. The establishment of secure links between nodes is then a challenging problem in WSNs. Because of resource limitations, symmetric key establishment is one of the most suitable paradigms for securing exchanges in WSNs. On the other hand, because of the lack of infrastructure in WSNs, we have usually no trusted third party which can attribute pairwise secret keys to neighboring nodes, that is why most existing solutions are based on key pre-distribution. Over the last decade, a host of research work dealt with symmetric key pre-distribution issue for WSNs and many solutions have been proposed in the literature. Nevertheless, in most existing solutions, the design of key rings (blocks of keys) is strongly related to the network size, these solutions either suffer from low scalability (number of supported nodes), or degrade other performance metrics including secure connectivity, storage overhead and resiliency in the case of large networks. In this work, our aim is to tackle the scalability issue without degrading the other network performance metrics. For this purpose, we target the design of a scheme which ensures a good secure coverage of large scale networks with a low key storage overhead and a good network resiliency.

Wsn Application In Oil Industry

Typical Use Of Sensors:

In the Oil and Gas Industry, the type of data sensed includes pipeline pressure, flow, temperature, vibration, humidity, gas leaks, fire outbreaks, equipment conditions etc. (Talevski et al., 2009) This is usually performed in typical application scenarios as described below:

Pipelines & Corrosion Monitoring: Pipelines are extensively used in the oil and gas industry including sub-sea, above ground, buried and gas pipelines. (Jawhar, Mohamed, Mohamed, & Aziz, 2008) Pipeline corrosion, especially for aging pipeline infrastructure leads to leaks, emissions and deadly explosions in production facilities and refineries. It is therefore crucial to perform real-time monitoring of flow, pressure build-ups, temperature changes, valve position to ensure safety, efficiency and streamline pipeline operation. WSN provide cheaper alternatives for this kind of monitoring. (Jawhar et al., 2008,Hatler et al., 2012)

Condition monitoring of plants: Organized sensor systems are able to perform preventive and predictive maintenance and improve post-fault diagnosis. Decisions are made after sensor measurements are obtained from realtime monitoring to determine the condition of components.(Akhondi et al., 2010) WSN can also be used to monitor Oil and Gas installations embedded in the ocean. In order to optimize production and to ensure safety, equipments and parameters

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
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have to be monitored. WSN can be used to monitor production processes, prevent or detect oil and gas leakage, enhance production flow and yield of wells, improve working conditions and better protect the environment. (Dalbro et al., 2008)

Wellhead Automation: WSN technology is usedin optimizing the process of well drilling. New health monitoring systems are also being deployed in harsh and remote locations like offshore rigs. (Hatler et al., 2012)

Oil exploration and Seismic Surveys: The growing demand for energy worldwide is driving oil exploration and efficient and less expensive alternatives like WSN will be at the forefront. WSN provides a means for real-time production monitoring with efficient acquisition and transmission of data. The technology fits well in harsh environments, has cost benefits and supports temporary deployments and sensor expansions. In the long run, if fully implemented, the derived benefits include remote equipment diagnosis, reduced equipment failures and shutdowns. (Cramer, 2012)WSN is also at the forefront of improved seismic surveys. The process of conducting surveys in deep and remote regions has been simplified and expanded, providing a possibility for millions of seismic sensors deployment around the world. (Cramer, 2012, Hatler et al., 2012)

Co-operative Communications

Cooperative communication refers to processing of this overheard information at the surrounding nodes and retransmission towards the destination to create spatial diversity, thereby to obtain higher throughput and reliability. Cooperative wireless communications can actually exploit interference, which includes self-interference and other user interference. In cooperative wireless communications, each node might use self-interference and other user interference to improve the performance of data encoding and decoding, whereas conventional nodes are generally directed to avoid the interference. For example, once strong interference is decodable, a node decodes and cancels the strong interference before decoding the self-signal. The mitigation of low Carrier over Interference (CoI) ratios can be implemented across PHY/MAC/Application network layers in cooperative systems.

Cooperative multiple antenna research — Apply multiple antenna technologies in situations with antennas distributed among neighboring wireless terminals.

Cooperative diversity — Achieve antenna diversity gain by the cooperation of distributed antennas belonging to each independent node.

Cooperative MIMO — Achieve MIMO advantages, including the spatial multiplexing gain, using the transmit or receiver cooperation of distributed antennas belonging to many different nodes.

Cooperative relay — Apply cooperative concepts onto relay techniques, which is similar to cooperative diversity in terms of cooperative signalling. However, the main criterion of cooperative relay is to improve the tradeoff region between delay and performance, while that of cooperative diversity and MIMO is to improve the link and system performance at the expense of minimal cooperation loss.

Relaying techniques for cooperation
Store-and-forward (S&F), Amplify-and-forward (A&F), Decode-and-forward (D&F), Coded cooperation, Spatial coded cooperation, Compress-and-forward (C&F),Non-orthogonal methods.

ZIGBEE

Fig Zigbee device

Zig-bee is a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4,2006 standard for wireless personal area networks (WPANs), such as wireless headphones connecting with cell phones via short-range radio. The technology defined by the Zig-bee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. Zig-bee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking.

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Zig-bee is a low data rate, two-way standard for home automation and data networks. The standard specification for up to 254 nodes including one master, managed from a single remote control. Real usage examples of Zig-bee includes home automation tasks such as turning lights on, setting the home security system, or starting the VCR. With Zig-bee all these tasks can be done from anywhere in the home at the touch of a button. Zig-bee also allows for dial-in access via the Internet for automation control.

Zig-bee protocol is optimized for very long battery life measured in months to years from inexpensive, off-the-shelf non-rechargeable batteries, and can control lighting, air conditioning and heating, smoke and fire alarms, and other security devices. The standard supports 2.4 GHz (worldwide), 868 MHz (Europe) and 915 MHz (Americas) unlicensed radio bands with range up to 100 meters.

Zigbee stack architecture :

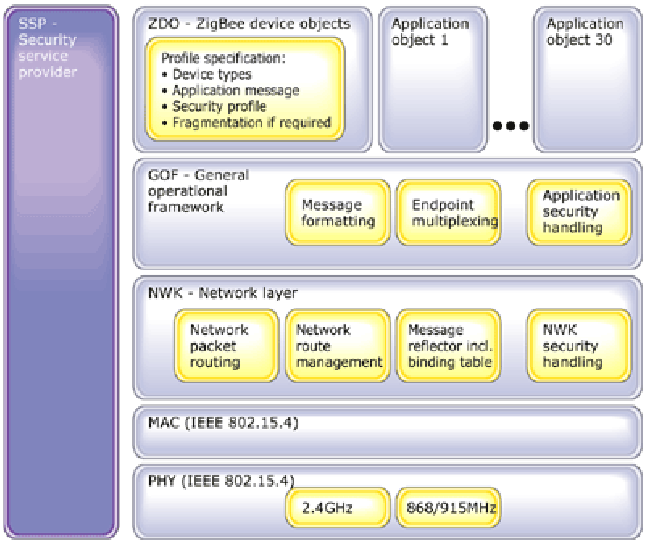

Fig 3.15 zigbee protocol architecture

ZigBee stack architecture:

It may be helpful to think of IEEE 802.15.4 as the physical radio and ZigBee as the logical network and application software, as Figure 1 illustrates. Following the standard Open Systems Interconnection (OSI) reference model, ZigBee's protocol stack is structured in layers. The first two layers, physical (PHY) and media access (MAC), are defined by the IEEE 802.15.4 standard. The layers above them are defined by the ZigBee Alliance. The IEEE working group passed the first draft of PHY and MAC in 2003. A final version of the network (NWK) layer is expected sometime this year.

ZigBee-compliant products operate in unlicensed bands worldwide, including 2.4GHz (global), 902 to 928MHz (Americas), and 868MHz (Europe). Raw data throughput rates of 250Kbps can be achieved at 2.4GHz (16 channels), 40Kbps at 915MHz (10 channels), and 20Kbps at 868MHz (1 channel). The transmission distance is expected to range from 10 to 75m, depending on power output and environmental characteristics. Like Wi-Fi, Zigbee uses direct-sequence spread spectrum in the 2.4GHz band, with offset-quadrature phase-shift keying modulation. Channel width is 2MHz with 5MHz channel spacing. The 868 and 900MHz bands also use direct-sequence spread spectrum but with binary-phase-shift keying modulation.

Sensing Methods

- Capactive Sensors: In this method, two metal plates are implanted inside the liquid tank. The capacitence of plates change when air between plates is replaced by liquid. That difference of capacitence is measured to estimate the level of liquid in the tank.
- Optical Sensors: Optical Sensors (like infrared) may be used to detect whether liquid is present between pair of transmitter-receiver or not. This method does not give precise measurement. It just idnicates presence of liquid at certain level in the tank.
- Pressure Sensors: The method is particularly useful for precise measurement of quantity of liquid. Pressure sensor is installed at the bottom of tank. It gives a pressure reading depending on the quantity of liquid in the tank. If one know the denstity of liquid, she can easily get the precise measurement of level of liquid.
- Floating Stick: A float is attached to a stick. Stick goes up as the liquid rises in

Temperature Sensor:-

Temperature sensor is used to sense the temperature. We have used a Temperature sensor called LM35. Irrespective of the application to which it is used, it gives the reading of the temperature. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. Temperature sensor is an analog sensor and gives the output

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into form of analog signal. This signal is feed to ADC which will convert it into digital form.

Gas Sensor:-

Gas sensor we are using is MQ-6. Sensitive material of MQ-6 gas sensor is SnO_2, which with lower conductivity in clean air. When the target combustible gas exist, the sensor's conductivity is more higher along with the gas concentration rising. MQ-6 gas sensor has high sensitivity to Propane, Butane and LPG, also response to Natural gas. The sensor could be used to detect different combustible gas, especially Methane, it is with low cost and suitable for different application.

Key Features of System: 1) Efficient way for wireless data logging of hazardous applications 2) Less time delays 3) Quick response time 4) Fully automate system 5) Robust system 6) Low power requirement

Applications: 1) Data logging in hazardous application such as nuclear plants, gas plants, chemical plants etc. 2) Wireless communication over long distances such as oil rigs. 3) Forest fire Detection. 4) Industrial Monitoring etc.

Conclusion & Future Work:

Oil and gas fields often span hundreds and even thousands of square miles across remote areas that often lack cellular coverage. Extreme outdoor conditions are typical in many of these fields such as intense cold, ice and snow, searing heat, heavy dust, high humidity, strong wind, torrential rain and salt fog. Oil and gas field communications require reliable and resilient, high capacity wireless networks that operate over large areas under extreme environmental conditions. Ideally, wireless oil and gas communication networks deliver broadband speeds and form a scalable foundation to securely support multiple applications that increase operational efficiency and safety on one cost-effective physical infrastructure.

In summary, zigbee wireless smart sensor platform is a new close range, simple low power, low data rate & low cost technology. It is based on IEEE 802.15.4 std. In our system we uses various features like Co-operative Communication whose goal is to increase communication rate & reliability .also we are using dedicated mobile to give the SMS. Here we can also add the no. of slaves, the idea is that if the slave goes out of range of PC master then the communication fails. All slaves placed in such a way that they will be always in range of the PC master. (ie we can use feature of collision avoidance protocol). Future research &development may continue to be focused on further improvements of the reliability & responsiveness & technology advancement on energy saving, power management, fault tolerance & smart routing

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