Industrial Fixed Broadband Wireless for Oil and Gas Industry - Microseismic Connectivity Case Study

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Abstract

Oil and Gas process automation applications are mission critical. Traditional wireless solutions may not be able to meet the requirement of these applications. As a result, an industrial wireless solution must be considered that provides high reliably, security and real time delivery for the process automation applications. This paper will provide an overview of how can industrial wireless technologies add value to the oil and gas industry, benefits and challenges. Furthermore, emphasis will be on the use of industrial fixed broadband wireless access (FBWA) for first mile field access. The successful field trial implementation of industrial FBW solution for microseismic application will be presented in this paper.

1. Introduction

Wireless Technology provides cost-effective and efficient connectivity solution for several oil and gas operations. Many remote facilities, processes and field operations can benefit from the 1st wireless mile access to be connected to the corporate process automation network (PAN) and this would result improving productivity, less downtime, faster and more accurate data collection and reduced capital and operating expenditures

In general, industrial wireless technologies can be classified into four main categories [1] based on their coverage area and bandwidth as shown in Fig.1:

- Wireless Personal Area Network (WPAN) – few meters
- Wireless Local Area Network (WLAN) – few hundreds of meters up to few Kilometers
- Wireless Metropolitan Area Networks (WMAN) – tens of Kilometers
- Wireless Wide Area Networks (WWAN)– tens up to hundreds of Kilometers

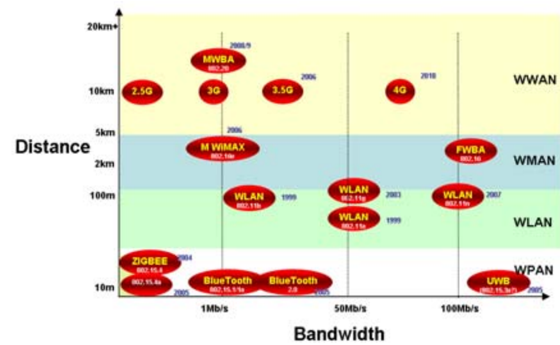

Fig.1: Industrial Wireless Classifications (bandwidth vs. distance)

On the other hand, process automation applications can be classified into three main groups based on their mode of operation (Fig.2):

- Process Safety wireless solution(s)
- Process Control wireless solution(s)
- Process Monitoring wireless solution(s)

			Importance of message timeliness increases
Safety	Class 0 : Emergency action	*(always critical)*	
Control	Class 1: Closed loop regulatory control	*(often critical)*	
	Class 2: Closed loop supervisory control	*(usually non-critical)*	
	Class 3: Open loop control	*(human in the loop)*	
	NOTE: Batch levels* 3 & 4 could be class 2, class 1 or even class 0, depending on function *Batch levels as defined by ISA S88; where L3 = "unit" and L4 = "process cell"		
Monitoring	Class 4: Alerting *Short-term operational consequence (e.g., event-based maintenance)*		
	Class 5: Logging & downloading/uploading *No immediate operational consequence (e.g., history collection, SOE, preventive maintenance)*		

Fig.2: Industrial process Wireless Classifications [ISA SP-100]

Several wireless solutions have been implemented to provide process monitoring for remote facilities such as well head monitoring and pipeline applications such as traditional WiFi (IEEE802.11a,b,g), Zigbee, GSM (SMS/GPRS), VHF/UHF radios and VSAT satellite wireless solutions. However, these solutions were designed to provide "best effort" remote monitoring.

WPAN and WLAN solutions are appropriate for in-plant process connectivity such as connecting scattered sensors, controllers, instruments and machines wirelessly. On the other hand, FBW provides potential cost saving be eliminating the need to deploy physical cabling (optical fiber) between different facilities and plants. Moreover, FBW provides adequate throughput for point-to-pint and point-to-multi-point configuration that fulfills the requirement of current and future oil and gas process automation applications including:

- Oil/Gas well heads automation
- Cathodic protection monitoring and control
- Energy Management
- Waste water management
- Vibration monitoring
- Power Monitoring System
- Condition-Based maintenance
- Remote surveillance and alerting solution
- Power monitoring
- Micro-seismic sensing application

2. Key Requirements for Industrial FBW

Fig.3 shows key elements required in the industrial wireless solution such as FBW to be effectively utilized for process automation monitoring and control in oil and gas applications are summarized below:

- Support real-time applications (deterministic)
- Offer reliable radio channel "reliability"
- Use open standards interfaces and protocols "interoperability." This provides protection for investment (interoperability between different vendors)
- Be as secure as a wired network "security"
- Uses robust and certified industrial products

Fig.3: Industrial Wireless Link Performance Parameters

2.1. Deterministic and Shared Access

FBW solution shall provide deterministic access mechanism either by enabling the scheduling "cyclic" criteria or by reserving "bandwidth" to specific application(s) in order to guarantee air time access of process automation critical remote nodes as shown in Fig.4. This involves the remote nodes being cyclically triggered and thereby receiving a pre-defined "time-slot" for the data transfer.

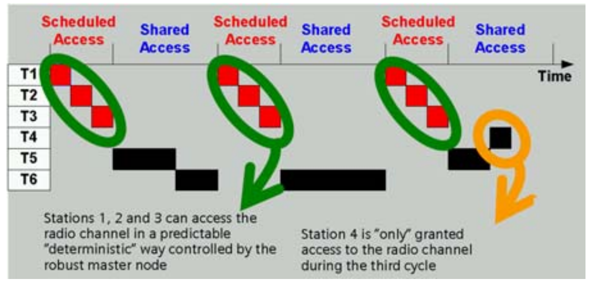

Fig.4: Wireless Deterministic Access for critical/time sensitive process applications

2.2. Redundant Radio Channels

It is crucial to use redundant wireless connection for oil and gas critical process automation applications. This could be achieved by having dual radio channels for the master and client nodes as shown in Fig.5. The 2.4GHz [3] and 5GHz ISM bands are potential frequencies to be used as dual Radio access where both signals (2.4 GHz and 5 GHz) are transmitted simultaneously to achieve extremely high level of radio channel reliability and to provide minimal interference wireless connections.

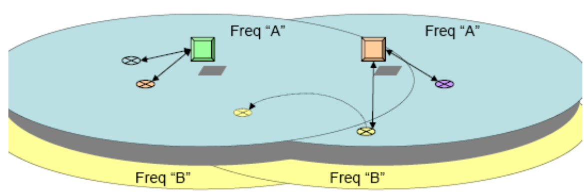

Fig.5: Redundant Radio Access for critical/time sensitive processes applications

2.3. Robust and Classified Materials

Wireless device used inside the classified area (zone) of a hydrocarbon facilities must adhere (and be certified) to the area classifications requirements to insure safe operation of wireless systems inside any classified areas of hydrocarbon facilities.

2.4. Secure Wireless Communication

Basic security settings and factory default settings for "operating" industrial wireless networks shall not be allowed under any circumstances. The use of Advanced Encryption Algorithm (AES) [2] can ensure fully secured data transfer over wireless channel. The AES encryption algorithm cannot be "cracked" with current technology. Moreover, proper Radio Frequency (RF) planning is needed to optimize wireless coverage and limits wireless signals propagation outside plants or facilities

3. Microseismic Connectivity Case Study

FBW solution was deployed to provide real-time broadband connectivity for the oil reservoir microseismic analysis and monitoring. This connectivity enabled engineers to optimize recovery of hydrocarbons and provided fluid flow path monitoring between wells as shown in Fig.6

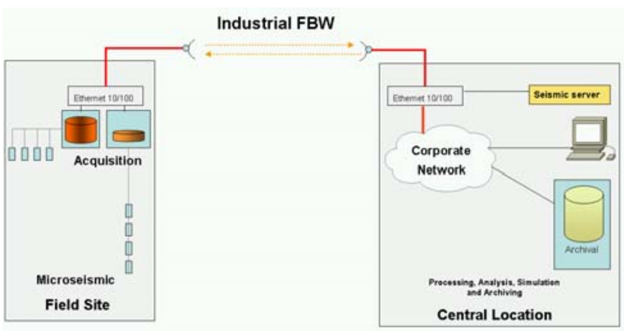

Fig.6: Industrial Wireless Link Performance Parameters

3.1. Field Test Results and Challenges

3.1.1. Test Results

Performance test procedure was developed to benchmark the flowing parameters:

- Link budget verification
- Throughput measurement
- Integrity test
- Wireless link survival test

Field results were very close to the calculated values as shown below:

- Transmit Power for primary link = 18dBm
- Received Power for primary link = -61dBm
- Transmit Power for secondary link = 18dBm
- Received Power for secondary link = -60dBm
- Avg. Throughput for Primary Link = 76Mbps "shown in Fig.7"
- Avg. Throughput for Secondary Link = 80Mbps

Fig.7: Throughput test Results

Online performance testing and benchmarking was developed to evaluate and validate the performance of industrial wireless systems for Process Automation applications. Key performance parameters such as Availability, Packet Error Rates (PER), Latency, Throughput and Utilization has been identified and monitored for the planned evaluation phase (Fig.8).

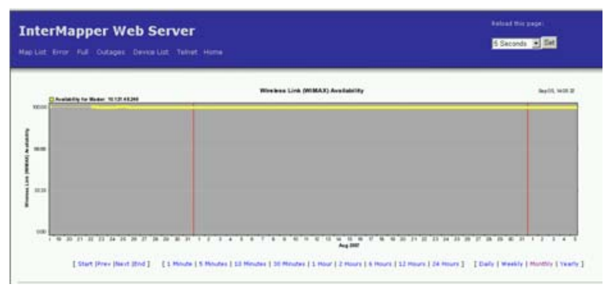

Fig.8: Online performance monitoring system for key performance parameters (availability, Packet Error Rates (PER), Latency, Throughput, Utilization,..etc.

3.1.2. Test Results

Failover mechanism was one of the challenges faced by the implementation team. Initially, wireless links ports where configured independently which resulted in about a 20 to 30 second delay for redundancy takeover process because of the slow Spanning Tree Protocol (STP). Port aggregation was deployed to overcome this problem and provide seamless failover redundancy. Moreover, Dynamic Frequency Selection (DFS) algorithm to manage frequency bands and use the least congested/interfered channel as shown in Fig.9.

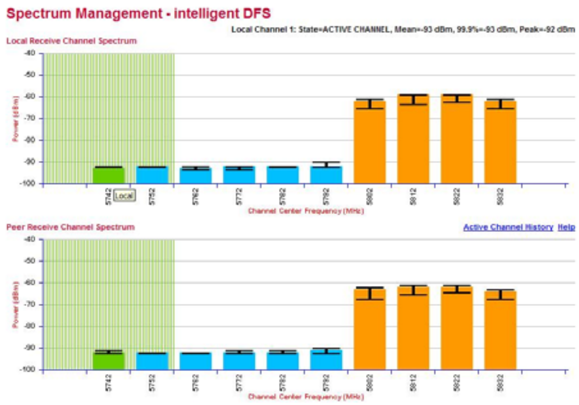

Fig.9: Dynamic Frequency Selection approach

4. Conclusion

Industrial Wireless solution provides cost effective and efficient connectivity for various oil and gas applications. It is very crucial to ensure deterministic and “guaranteed” access for time critical applications in a point-to-point and point-to-multi-point architecture/mesh architecture. Moreover, providing redundant links “radio” and complying with hazardous area’s classifications is necessary to ensure the reliability of wireless connectivity and safety of hydrocarbon.

FBW is a potential wireless technology that would provide 1st mile access for plant and process operations such as Intelligent Field “I-Field,” SCADA and process remote monitoring and automation applications (e.g, microseismic application). FBW solution showed reliable and secure communication solution for field connectivity with sufficient throughput capability (70+ Mbps) for advanced microseismic applications.

Furthermore, open standard Industrial wireless solution (IP based) must be properly integrated and interfaced with the wired solution “corporate LAN/WAN” to provide seamless end-to-end connectivity.

10. References

[1] Rahim Tafazolli, “Technologies for the Wireless Future”, 2nd Volume, John Wiley & Sons Ltd, 2006.

[2] Rajeev Shorey, “Mobile, Wireless, and Sensor Networks - Technology, Applications, and Future Directions”, IEEE Press, 2006

[3] Apprion, “The Wireless Plant of the Future: From Roadmap to Reality” 2006.

[4] Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification, IEEE Std. 802.11, 1997

[5] ISA SP-100, Wireless Systems for Automation (www.isa.org)