Emerging trends of Wireless technologies for Process Control and Monitoring in Continuous Manufacturing industries.

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Abstract: Manufacturing Industry such as Petroleum Refinery is being operated with a huge Hydrocarbon inventory. Complex with reliable control and monitoring of process parameter provides safe and sustainable business outcomes. Conventionally wired approaches like HART, 3-15 psig, 4-20 mA, Foundation fieldbus, Profibus are being adopted in the majorities of Refineries. Hence advanced communication approach like Wireless Technology is gaining more popularity among its class. Ease of installation, less maintenance, Cost effectiveness are the key benefits for this approach. In this paper adoptability of wireless technology like WirelessHART in manufacturing industry has been discussed with due relevant data and technical aspects

IndexTerms - **Instrumentation, WSN, WirelessHART, IEEE 802.15.4, IEC 62591, ISA 100.11a.**

I. INTRODUCTION

It has been witnessed that emergence in technology is directly affects it's downstream applications. However, in the case of Communication technology, recently Wireless gained a huge appreciation in various sectors. Evolvement of new technology is always challenging for its proposed purpose. Various wireless solutions like GSM, EDGE, HSDPA, LTE, LTE-advance, Wi-Fi, Bluetooth, RFID and WLAN have been extensively used in Domestic or Commercial application. It is proved that industrial environment has various lacking factors due to which there is errors in signal transmission. There are electrical and thermal noises, interferences, vibrations and structural obstacles which degrades the signal quality [1]. There is also other communication errors occur due to attenuation of signal which is due to distance between the transmitter and receiver, and the problem of multiple transmission paths which is mainly due to direction, reflection and scattering of the wave [2]. It is also witnessed that the errors in wireless links are for the short time only and again it gains its original healthy state [3]. Where as in wired network majority time error remains in the system due to permanent failure of cables and connector or communication a component [4].

However, it demands robust, reliable and efficient wireless solution. Industrial closed control loops are very much critical to have special attention; As the Petroleum Refinery processes Hydrocarbon in a huge amount, delay/Error in controlling the process parameters (i.e. Pressure, Temperature, Level, Flow etc.) may lead to heavy asset lose or catastrophic effect.

Keeping present demand in mind, it can be said that Wireless Networks for industrial use can be best suitable for last mile connections in process control or in monitoring purpose, which is depending on the application [5]. Data extraction is also less complex in wireless media compared to wired one. The traditional instrumentation philosophy which was developed for high reliability industrial application is also proved to be more complex against wireless solutions for the said purpose [6].

As shown in figure 1, as per the Clayton Christensen's model of innovation, there are low cost and high cost products which provide low end and high end performance simultaneously. However, wired instruments is providing high end performance and hence costly too. At the other side, evolves wireless technology is increasing its stack in market mainly in main stream adoption zone which is highlighted in oval shape [7].

The WirelessHART (IEC 62591), IEEE 802.15.4 and ISA 100.11a are the standards specially made for Industrial automation. All have their own features and limitations, which is discussed later in this paper. Collectively using wireless infrastructure instead of wired one is providing following advantages:

- Economical: It is cost effective when large number of field devices are installed.
- Manageable: Failure in case of wireless devices are transient in nature, Hence it can be cured with due preventive steps. However, in wired instruments failure it is permanent without prior indication.
- Flexible: Once network has been established it is very much convenient to add other devices in the network. Security. Wireless security extends to the field instrument and does not rely on physical security of the transmission medium.

- Redundant network: Practically it is not possible to establish redundant data path in wired instrument's network. Whereas in wireless network if Mess topology is being adopted we will have redundant channel for communication. It is also proved that redundant wireless link is more reliable than non-redundant wired channel.
- Redundant at plant: When the same measured data in provided with wireless instruments there will be additional redundancy achieved. It field device is of independent protection layer, wireless will have more advantage over wired one [7].
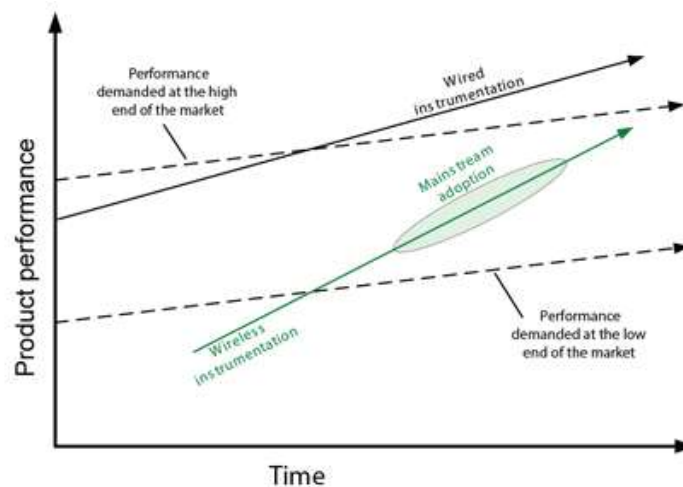
"Figure 1. Clayton Christensen's model of innovation"

Generally wireless instruments are located to the sensing location which is far away from the control room and hence they contain batteries. It also induces some disadvantage as below.

- Limitation of Power pack(Battery): Currently, most of the recognized industrial instruments are running over 2 years, keeping minimum update rate. Maintenance of battery for wireless devices is also a constrain as large number of device will increase the frequency of maintenance and hence cost.
- Conversion limitation: If there is availability of power than an ISA100 Wireless adapter can convert a wired instrument to wireless. If there is limitation of power to device there will be constrain to update the philosophy.
- Update rate: For process parameter monitoring data required at predefined small interval, as the frequency of update increases there will be increase in power consumption. For controlling purpose update rate is as high as possible for efficient process control. So, there will be always trade of between update rate and power requirement unless alternate means of power is being provided.

II. WIRELESS HART

1. WirelessHART

WirelessHART is a WSN technology developed based on the HART(Highway Addressable Remote Transducer Protocol). It is a multi-vendor, interoperable and open wireless standard, It was defined for the requirements of field networks [8].

WirelessHart uses a self-organizing, time synchronized and self-healing mesh architecture. It operates in the 2.4 GHz ISM band using IEEE 802.15.4 standard radios. It was developed upon the starting workout of Dust's TSMP technology [9]. In April 2010, It was approved by the IEC (International Electrotechnical Commission) which was the first wireless international standard as IEC 62591 [10].

It is an integrated wireless communications protocol for process automation purpose, mainly evolved for industrial application. It provides facility to be wireless to it's mother technology(HART) devices. It uses mesh networking topology in which each device is serving as a router/path for messages from one device to other devices. We can say that the device itself do not have direct access to the gateway (excluding end device), rather message is passing in multi hop manner. One device pass data to its nearest one and it again forward data bits to its neighborhood device until data reaches to the destination. This technique will increase the redundant path for the message and increase the reliability of the network in typical harsh industrial environment.

There are main three elements of the WirelessHART network as below:

- **Wireless field devices** directly mounted on the process connections.
- **Gateways** which act as a link between field devices and host application. It also connects device to the other plant network which is typical high-speed in nature.
- **A Network Manager** which is tool to configure the network, assigning the schedule for communication in devices, routing configuration and monitoring of other network related parameters. It can be integrated into gateway, host software or controller itself [11].

A typical WirelessHART mesh network is shown in *Figure 2.*
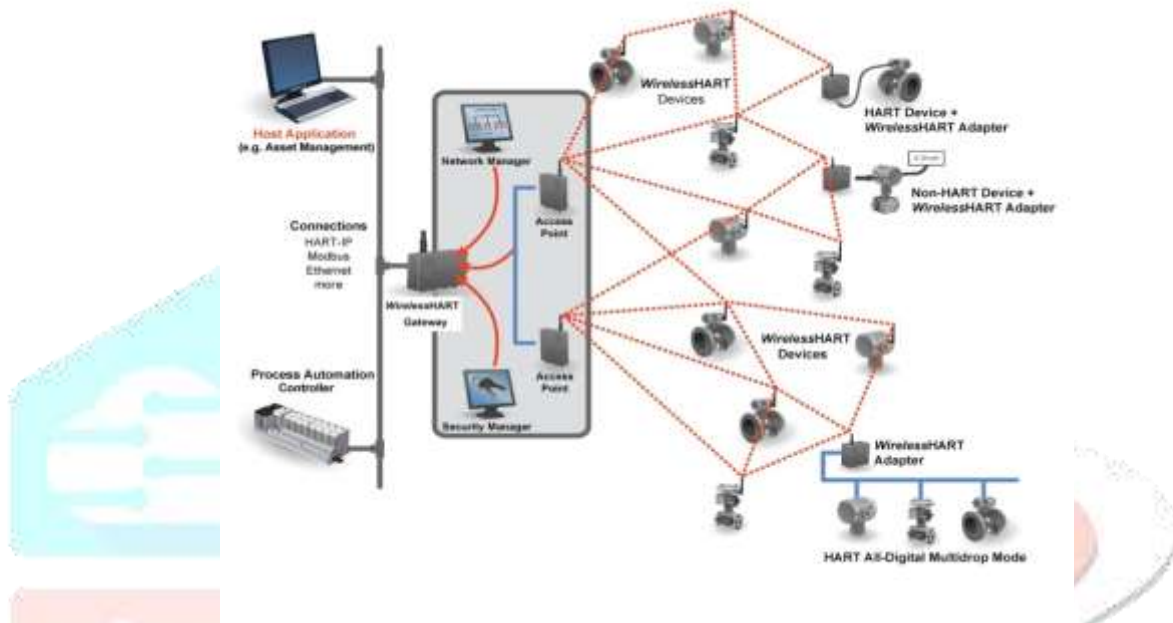
"Figure 2. WirelessHART MESH network."[11]

2. Applications:

WirelessHART® can be applied to number of process applications. Where the process industries are spreaded over differing geographical terrain. Typical applications are as below:

- Process parameter monitoring and measurements which are costly for conventional methods.
- Machine condition monitoring system. (MCMS)
- Environmental stake gas monitoring, energy conservation management and other statutory compliance.
- Inconvenient installation condition (i.e. Humidity, temperature and corrosion) where wired device can't be installed.
- Movable equipment.
- Rotary equipment.
- Management of asset, diagnostics and predictive maintenance
- Least critical and simple closed loop control.
- Pump API seal flush plans.
- Secondary seal plans.

3. Adoption Philosophy:

WirelessHART protocol can be adopted for closed loop control and open loop monitoring applications. Recent trends shows that majority of clients are preferring to adopt it in non-critical monitoring purpose only as it is general tendency not to implement new technology in critical application. Furthermore wireless control applications is continuing to evolve with the introduction of discrete output devices for performing simple control functions. Below is the *Table 1*, which provides a high end summary for selection of the right technology considering the mission critical use case and other technical and non-technical consideration.

Table 1. Selection of right protocol [12].

	Safety systems	Critical control	On-off control	In-plant monitoring	Remote monitoring
Conventional					
Fieldbus					
WirelessHART					

Legend	Based on technical and/or cost considerations
	Most appropriate solution
	Appropriate in some cases
	Lease effective solution

III. RECENT ADVANCEMENT

1. Other Industrial Standards.

ISA 100.11a, WSAN/WISA(Wireless Interface for Sensors and Actuators) [13], WirelessHART, IWLAN and ZigBee are popular standards available in market for process industry. Comparison of them is in *Table 2* below.

Table 2. Comparison of Industrial standards[14]

	IWLAN	ZigBee	WirelessHART	ISA100.11a	WISA
Bandwidth(MHz)	22	2	2	2	1
Channels, Selections	14, Static	16, Static	15, Dynamic	15, Dynamic	77, Dynamic
Data rate	11-54 Mbps	250 Kbps	250 Kbps	250 Kbps	1 Mbps
Freq. Band(GHz)	2.4, 5	2.4	2.4	2.4	2.4
MAC Layer	IEEE 802.11	IEEE 802.15.4	Proprietary	Proprietary	Proprietary
Radio	IEEE 802.11 b/g/a	IEEE 802.15.4	IEEE 802.15.4	IEEE 802.15.4	IEEE 802.15.1
Topology	Star	Star, Full-mesh	Full-mesh	Star, Star-mesh, Full-mesh	Cellular, Star

Amongst all WirelessHART is seems to be most suitable due to High Degree of reliability, Slotted communication to reduce latency, Open, Ease of backward integration and battery optimization.

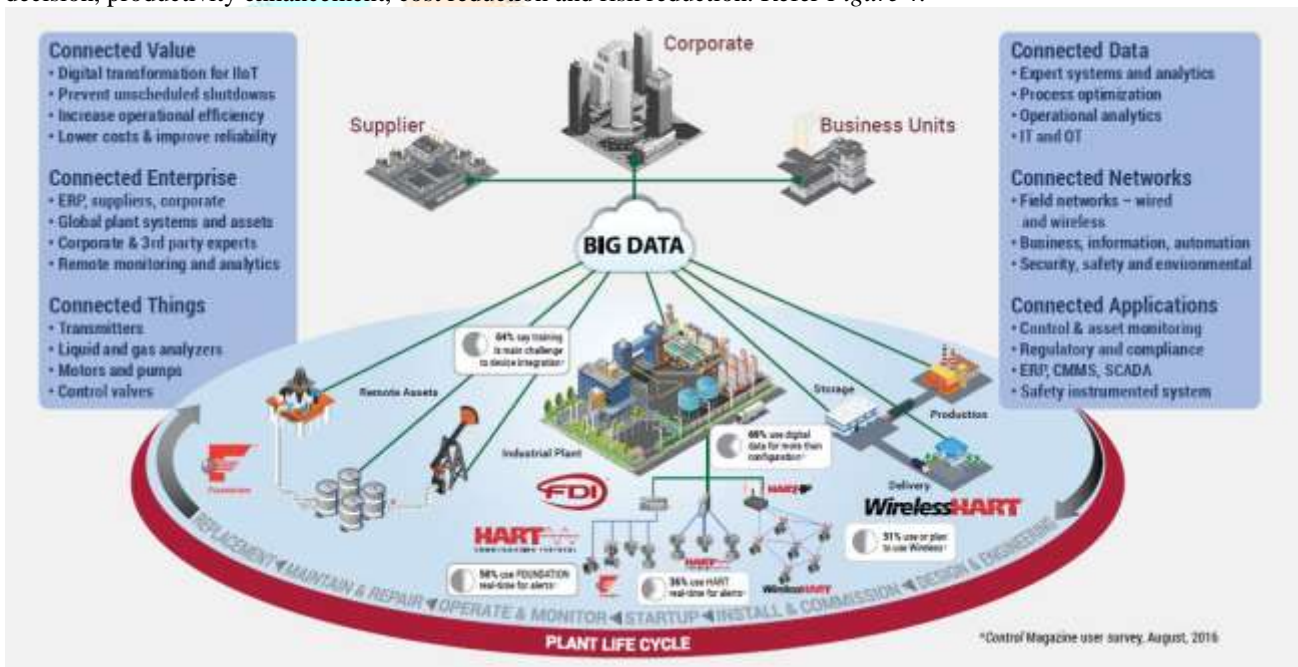### 2. Self-Powered Field Instruments:

Presently, most of the research scholars are working on integrating Field wireless device with Energy harvesting technique. ABB has announced world's first self-power Temperature Transmitter. The sensor of instrument is powered by the thermoelectric generator which works on difference of temperature of process to surroundings. It can gain energy form Hot or Cold process condition [15]. It is shown in *Figure 3* below.

*"Figure 3. ABB's TSP300-W WirelessHart sensor with EH"*

3. HART and IIoT:

HART technology can be said as a driving the digital transformation technology for more than 20 years by making plant operations smarter. Currently, It is being embedded in millions of intelligent devices and systems and has enabled end users to make smarter decision, productivity enhancement, cost reduction and risk reduction. Refer *Figure 4.*

"Figure 4. HART towards IIoT"[16].

As per the current trend HART seems to be the most used digital communications technology deployed in the process control application, with an estimated more than 40 million installed field instruments worldwide. Refer *Figure 5*. It has a proven track record for nearly of 25. From device setup to commissioning, to device troubleshooting to diagnose, users have experienced and gained many benefits of getting connected to the smart information in their intelligent measurement devices. As reported 75% of the client trust on HART technology to have benefits on money and time.
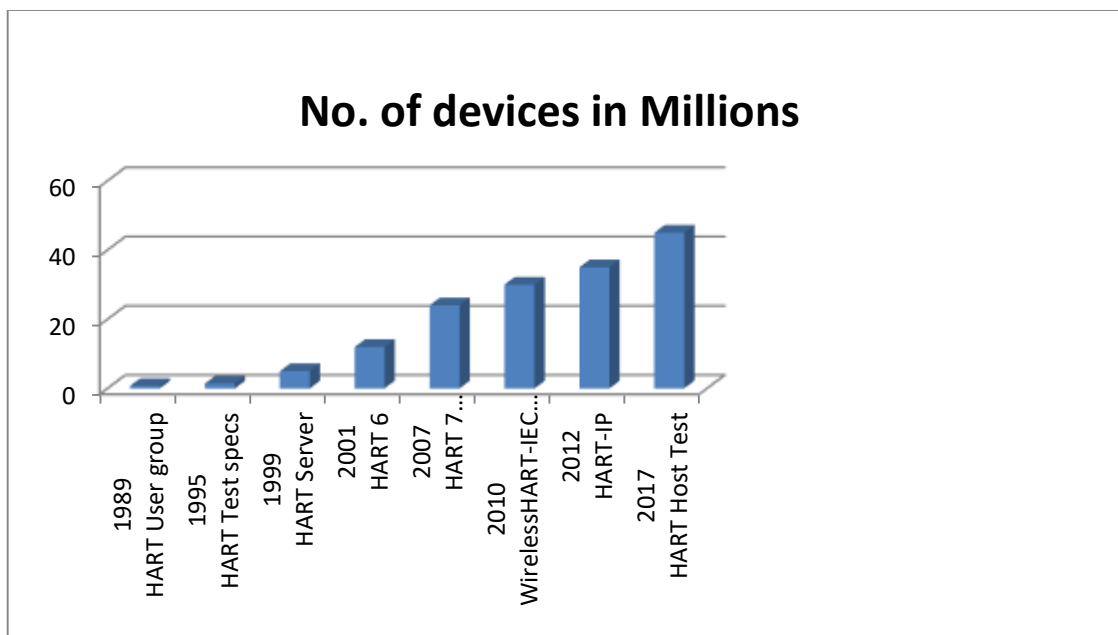
"Figure 5. Increasing No. of HART devices"[16].

IV. CONCLUSIONS

In this paper we have discussed the need of hour of Industrial Automation, where wireless is proven to be the best suited solution. As increasing demand of standardization, in last three decades numbers of standards are derived. We have also compared these standards. WirelessHART is best suitable as it provided most reliable and robust industrial standard for physical layer. It also aims to be integrated towards Industrial Internet of Things. Further research work on optimizing power management of field device, usefulness in closed control loop and enhance security are to be scrutinized.

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REFERENCES

[1] M. Bai, H. Atiquzzaman, \Error modeling schemes for fading channels in wireless: A survey," IEEE Communications Surveysand Tutorials, vol. 5, no. 2, pp. 2{9, 2003.}

[2] P. Di Marco, C. Fischione, F. Santucci, and K. H. Johansson,Modeling IEEE 802.15.4 Networks over Fading Channels,"ArXiv e-prints, Sep. 2012.

[3] A. Willig, M. Kubisch, C. Hoene, and A. Wolisz, \Measurements of a wireless link in an indu strial environment using an IEEE 802.11-compliant physical layer," IEEE Transactions on Industrial Electronics, vol. 43, pp. 1265{1282, 2002.}

[4] P. S. Marshall and J. S. Rinaldi, Industrial Ethernet, 2nd ed. ISA: The Instrumentation, Systems, and Automation Society, 2005.

[5] Zhao, G. Wireless sensor networks for industrial process monitoring and control: A survey. Netw. Protoc. Algorithms 2011, 3, 46–63. [Google Scholar]

[6] Johnstone, I.; Nicholson, J.; Shehzad, B.; Slipp, J. Experiences from a wireless sensor network deployment in a petroleum environment. Proceedings of the 2007 International Conference on Wireless Communications and Mobile Computing (IWCMC '07), Honolulu, HI, USA, 12–16 August 2007; pp. 382–387.

[7] Jay Werb, What are the Cost Benefits of Industrial Wireless?, InTech Magazine, issue-Nov/Dec 2014, http://automation.isa.org/2015/08/what-are-the-cost-benefits-of-industrial-wireless/. Accessed 01 Oct 2017

[8] Online document, Creative Commons Attribution-ShareAlike, https://en.wikipedia.org/wiki/WirelessHART. Accessed 01 Oct 2017

[9] Andrew Bond, Uncharacteristic Outbreak of Common Sense" in Wireless Wars, Industrial Automation Insider, issue Nov-2007. http://www.controlglobal.com/articles/2007/368/?page=1

[10] Online Document, Hartcomm Group . http://hartcomm.org/hcf/news/pr2010/WirelessHART_approved_by_IEC.html

[11] Online Document, Fieldcomm Group. https://fieldcommgroup.org/technologies/hart/hart-technology

[12] System Engineering Guidelines IEC 62591(WirelessHART), 00809-0100-6129, Rev AB February 2016

[13] WhitePaper_IntroductiontoWISA_V2, Richard Steigmann, ABB STOTZ-KONTAKT GmbH, Germany; Jan Endresen, ABB Corporate Research, Norway. July 2006

[14] WINA, choosing the right wireless technology for industrial applications, July 2009 Webinar

[15] Online document, drivesncontrols.com, Product news, 20 May 2015.
http://drivesncontrols.com/news/fullstory.php/aid/4811/_91World_92s_first_92_wireless_temperature_sensor_harvests_heat_energy.html

[16] Fieldcommgroup, Document Number: PS10037, Rev. 1.0.
https://www.fieldcommgroup.org/sites/default/files/technologies/hart/HART%20brochure%20web%20view.pdf