# Wireless Protocols for Critical IoT

Case study.

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## NIST measurement campaign

A public study was conducted by the NIST (National Institute of Standards and Technology, USA) to finely measure the communication channel in different industrial environments in order to check, by analysis, that the use of current standards offers a solution adapted to these environments. A summary of the measures and studies is available in full here :

`http://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.1951.pdf`

**Measurement locations** An extract of the final report based on these measurements has been distributed to you. In this report, we present the industrial environments where the measurements were taken. It also offers a description of the measurement conditions.

**Q1. Understand** Describe the measurements that were carried out and the 3 industrial environments from the documents provided to you.

**Q2. Delay spread et 802.15.4** One of the conclusions of the report is the presence of a strong channel spread due to the presence of obstacles in industrial environments. The IEEE802.15.4 technology has a bit rate of 250 kbits / s, and a symbol rate of 62.5 ksymbols / s. Does such a multi-path communication channel greatly degrade the transmission of IEEE802.15.4 frames ? Please, justify your answer.

## WirelessHART

The WirelessHART protocol is based on the digital communication chain of IEEE802.15.4. In this technology, a centralized controller defines a superframe where each slot lasts 10ms. An acknowledged communication (transmission of the frame + ACK) can be carried out in a slot. The maximum size of a transmitted frame is 127 bytes.

**Q3. First verification** Is it possible to send a frame of maximum size and an ACK in one 10ms slot ?

**Frequency hopping** Similarly to the TSCH mode of IEEE802.15.4, WirelessHART leverages frequency hopping. There are 16 orthogonal logical channels that can be assigned to a communication link. For each logical channel, at every superframe, the actual frequency between the source and destination nodes changes.

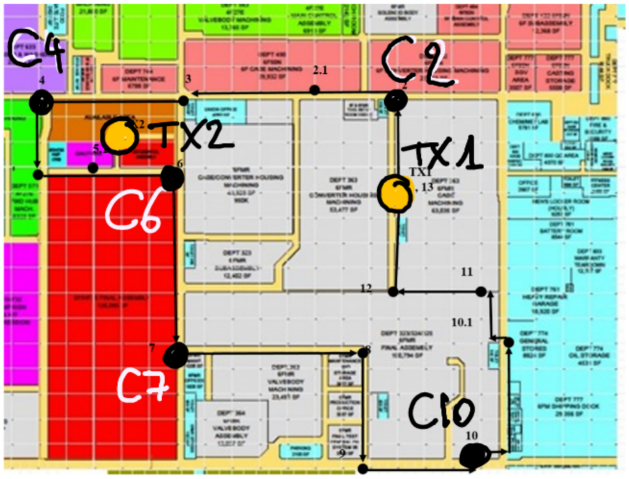
In Wireless HART, and this is different from TSCH, the ressource allocation is made by a central controller that decides on the assignment of time slots and logical channels to a communicating pair of nodes (source to destination node).

**Q4.** If we assume that a superframe is composed of 10 time slots, please plot one of the possible allocations that can be made by a controller that wants to assign 7 links created by the transmissions of 5 nodes as follows :

- B transmits a data frame to A and C
- C transmist a data frame to A
- D transmits a data frame to A and C
- E transmits a data frame to C and D

**Rolling out WirelessHART** We are interested in the deployment of sensors on the *outer loop route* of the automobile assembly plant. We want to deploy the following wireless sensors :

- At point 2 : Sensor C2 emits a frame every 60ms.
- At point 4 : Sensor C4 emits a frame every 90ms.
- At point 6 : Sensor C6 emits a frame every 180ms.
- At point 7 : Sensor C7 emits a frame every 60ms.
- At point 10 : Sensor C10 emits a frame every 40ms.




**Q5. Assigning sensors to Controllers** Two controllers (APs) are rolled out at the locations of TX1 et TX2 antennas. They only collect the data transmitted by the sensors. We will call these two controllers TX1 et TX2 as well.

Which access point could we associate the 5 sensors with ? What are the elements that would help us in making this association ?

**Q6. Size of the superframe** Propose the size of the superframe allowing all these flows to be transported by assuming that the sensors are associated with the controllers as follows :

— C2 associated to TX1.
— C4 associated to TX2.
— C6 associated to TX2.
— C7 associated to TX1.
— C10 associated to TX1.

**Q7. ARQ** To make communication more robust, each transmission is allocated two communication slots, in two consecutive superframes. How to reserve these redundant slots in the superframe ?

**Q8. Mesh network** We realise that the error rate on the link which connects C7 to TX1 is too high. We then configure C6 so that it becomes a router and retransmits the frames from C7 to TX2. How to modify the superframe to integrate this routing operation ?