Poster: Dimensioning UWB Industrial IoT Cells to Operate under Welding Electromagnetic Interference

Denis Chernov
Lakeside Labs GmbH
Klagenfurt, Austria
chernov@lakeside-labs.at

Jorge F. Schmidt
Lakeside Labs GmbH
Klagenfurt, Austria
schmidt@lakeside-labs.at

Marcel Schwaiger
pewag Austria GmbH
Kapfenberg, Austria
lsr@pewag.com

Abstract

Resistance welding is known to generate Electromagnetic emissions that can impair wireless transmissions. This poster studies the impact of these emissions on the feasible communication range of ultra-wideband (UWB) technology. Our results are based on extensive packet loss measurements at different link distances and propagation conditions in an industrial welding facility. The resulting characterization can help the design of an industrial IoT solution for production monitoring based on UWB.

1 Introduction

Wireless sensing has become a central part of industrial facilities where ease of production floor reconfiguration or monitoring of long-standing equipment are needed. These applications typically require data rates and reliabilities higher than those attained by mature industrial technologies like ZigBee, ISA100, and WirelessHart [1]. Recently, UWB emerged as a competitive candidate for industrial monitoring use cases [2, 3], going beyond the strong focus of UWB on localization applications.

The wireless monitoring of industrial production facilities is challenging because of the electromagnetic interference generated by large machines [4]. Specifically, resistance welding using high currents is employed in many manufacturing industries. The high currents involved generate significant magnetic fields around cables, work pieces and electrodes. These fields have been studied and characterized to guarantee healthy working conditions for operators [5]. However, their impact on the performance of wireless communication technologies has received much less attention.

In this context, our project ConSens focuses on the development of a suitable protocol stack to establish UWB as a reference technology for industry 4.0 condition monitoring applications. We present experimental results corresponding to an industrial chains manufacturing facility where heavy welding machinery impairs the successful delivery of packets from a network of UWB sensor nodes. Our characterization of the packet loss rates determines the number of access points needed for reliable coverage of a production hall. It also gives insights on how to properly allocate resources for the retransmission of lost packets. Such retransmission channel can guarantee the reliability requirements of monitoring applications in the event of random link outages. Our measurements indicate that UWB is a strong candidate to support industrial wireless condition monitoring.

2 Industrial Environment

The packet loss rate of a UWB wireless sensor network deployment is tested in the medium-sized chains manufacturing facility from Fig. 1, where the arrangement for one welding station is shown. A map of the deployment area within the production hall is detailed in Fig. 2, where each yellow square corresponds to the welding station in the middle of a production line (grey box) like the one in Fig. 1.

Figure 1. Production line for a welding machine.

The deployment area comprises 12 welding stations, of different power and operating at different welding frequencies. These machines create a complex electromagnetic interference scenario that impairs the reception of the UWB transmissions. The environment is essentially static. The measurements goal is to determine the maximum link distance over which a reliable communication can be attained.

3 Experimental testbed

Our testbed consist of battery operated nodes carrying a DW1000 UWB chip, common in ranging applications. The

Figure 2. Machine and node locations in the factory hall.

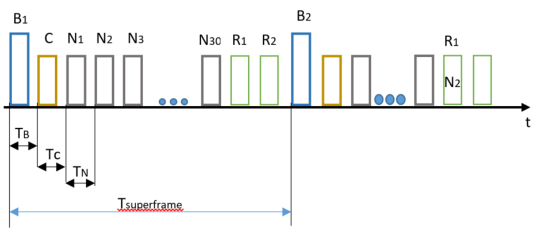

Figure 3. TDMA structure of our UWB testbed.

maximum SPI speed is 20 Mhz, and our routine for sending one packet with 127B payload includes: 1)SPI setup and transmission of data from MCU to DW1000, 2) preamble insertion, and 3) data transmission. In total 416 s are needed for transmission of 125B (2B are reserved for auto CRC16) with 6.8 Mbps data rate, and 128 bits preamble settings.

Our measurement network follows a star topology with a TDMA MAC (summarized in Fig. 3) having one beacon and fixed slots size. The traffic schedule is controlled centrally by an acces point (AP) through the beacon messages and not exchanged between nodes. Every node counts time for its communication window after receiving a beacon. Retransmission slots are reserved for packet recovery, being a goal from our measurement the determination of the amount needed. Network scaling is achieved by adding slots to the superframe TDMA structure as new nodes join the network. The new slots are advertised in the next beacon message.

4 Packet-loss Characterization

We measured 25 UWB links within the production area, capturing transmission distances from 20 to almost 34 m and different propagation conditions, as shown in Fig. 2. The green dot represents the position of the AP collecting all messages from the nodes. Nodes are placed forming three approximate semi-circles around the AP, at mean distances of 20, 30, and 35 m from it. Having several nodes at about the same distance to the AP with different propagation conditions allows to capture average performance.

Figure 4 shows the success rate results obtained from our

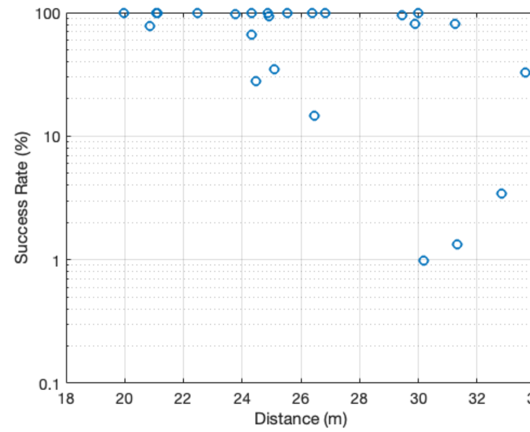

Figure 4. Success rate for all measurement points.

experiments with 10,000 packet transmissions per node. We observe that there is a strong degradation of the success rate for nodes at distances larger than 24 m. Our measurements of multiple propagation conditions indicate that although several long links have good performance, the performance on the degraded ones is large enough to prevent packet recovery. On the other hand, the mild loss rate observed in some nodes at around 21 m from the AP can be compensated with practical retransmission mechanisms.

5 Conclusions and Next Steps

We measured average packet loss performance of UWB in presence of machinery electromagnetic interference. Our results show that nodes up to 24 m away from the access point can be reliably reached. Packet losses up to that range can be recovered with the reservation of 1 or 2 retransmission slots. Our next step is the implementation of different policies for the allocation of those slots.

Acknowledgments

This work was partly funded by the Austrian Klima und Energiefonds under grant No. 881161 ("Condition and energy monitoring with innovative, ultra-reliable wireless sensor networks") in the 6. call of the energy research ("Energieforschung") program of the Austrian Research Promotion Agency (FFG).

6 References

[1] S. Mumtaz, A. Alsohaily, Z. Pang, A. Rayes, K. F. Tsang, and J. Rodriguez, "Massive Internet of things for industrial applications: Addressing wireless IIoT connectivity challenges and ecosystem fragmentation," *IEEE Ind. Electron. Mag.*, vol. 11, no. 1, pp. 28–33, March 2017.

[2] J. Schmidt, D. Chernov, M. Pauritsch, and C. Bettstetter, "Study of a self-powered UWB sensor network for industrial applications," in *Proc. European Wireless Conf.*, Arhaus, Denmark, May 2019. [Online]. Available: https://ieeexplore.ieee.org/document/8835943

[3] J. Schmidt, D. Chernov, and C. Bettstetter, "Towards industrial ultra-wideband networks: Experiments for machine vibration monitoring," *IEEE Access*, vol. 8, no. 1, pp. 42 576–42 583, Dec. 2020. [Online]. Available: https://doi.org/10.1109/ACCESS.2020.2976846

[4] H. Myers, "Industrial equipment spectrum signatures," *IEEE Transactions on Radio Frequency Interference*, vol. 5, no. 1, pp. 30–42, 1963.

[5] G. Melton, *Measurement and analysis of magnetic fields from welding processes*. HSE Books, 2005.