Designing Low Complexity Channel State Indicators for Channel Aware LPWA Networks Using an USRP-based Experimental Platform

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An USRP-based (Universal Software Radio Peripheral) experimental platform is used to acquire radiofrequency digital baseband (DBB) signals. The goal is the extraction of low complexity Channel Analysis Signals (CAS) and Channel State Indicators (CSI) to feed a classifier capable of accurately recognizing different propagation scenarios: undisturbed channels and channels affected by mobility-induced fading, or interference. The ultimate goal is the design of channel aware protocols for ultra-low power LPWA networks.

Keywords: Internet of Things (IoT), Low Power Wide Area Network (LPWAN), Channel State classification, Energy saving.

1 Introduction

Current Low Power Wide Area Network (LPWAN) wireless transceivers are designed, or configured at deployment time, to function assuming a worse-case applicative scenario. Most of the time, they waste a significant amount of energy when operated under favourable channel conditions. This fact can be leveraged to minimize the average power consumption of a transceiver and thus improve the lifetime of the autonomous node. However, in order to select the optimum trade-off between transceiver performance and amount of saved energy, without impacting transmission quality, accurate and energy efficient channel state classification is a necessity.

We designed an USRP-based platform to carry out experiments where the channel transmission quality can be controlled. Channel Analysis Signals (CAS) are implemented and recorded in realistic conditions when interferers or mobility-induced fading phenomena are present during the transmission. Our further goal is to develop Channel State Indicators (CSI) that can be used as input features in a channel state classifier.

We are focusing on the LPWA communication technologies because these IoT networks are deployed for km-range applications and have particularly stringent power consumption requirements. The large distances involved imply that the RF communication channel will have a wide dynamic range, making it necessary, and particularly for systems employing ISM bands, to recognize at least the following channel states: undisturbed channels, mobility-induced fading channels, or interference channels.

2 Experimental setup

The USRP-based experimental platform (Figure 1) is composed of three universal software radio peripherals (USRP), the first one is used as transmitter (Tx), the second as receiver (Rx) and the third as interferer (Ix). The USRPs are N210 models [1] from Ettus Research with WBX [40 MHz - 2200 MHz] daughter-board [2].

We have implemented radio transceivers based on a variant of the IEEE 802.15.4-2015 LECIM FSK PHY standard [3] which is an LPWA standard dedicated to critical infrastructure monitoring. The IEEE 802.15.4-2015 LECIM FSK PHY digital baseband receiver algorithm is detailed by the Figure 2.

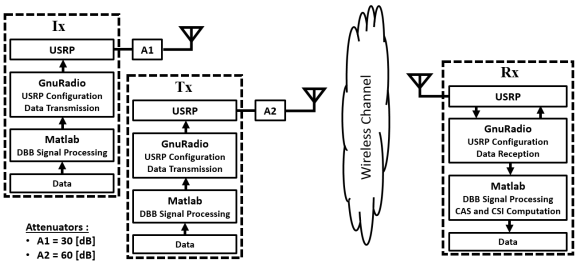

Figure 1: Illustration of the USRP-based experimental platform.

The experiment is conducted in different propagation scenarii : transmission trough an undisturbed channel, with the presence of interferences and with human and object mobilities. The obtained data is split into two sets, one is used to train classifiers and the other one for the validation step.

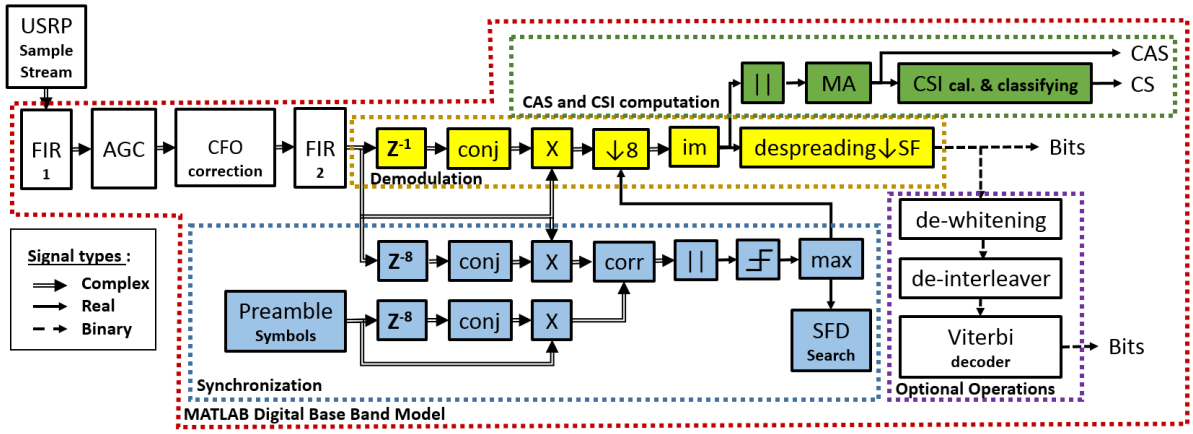

Figure 2: IEEE 802.15.4-2015 LECIM FSK PHY digital baseband receiver algorithm with CAS, CSI computation and CSI classification to provide a Channel State (CS) output.

3 Results

In our investigation, this USRP-based platform provides realistic data to compare different CAS and CSI in terms of classification performance. The Figure 3 shows examples of CAS and ACC (Average Crossing Count) for the different propagation scenarios. The ACC is one example of CSI.

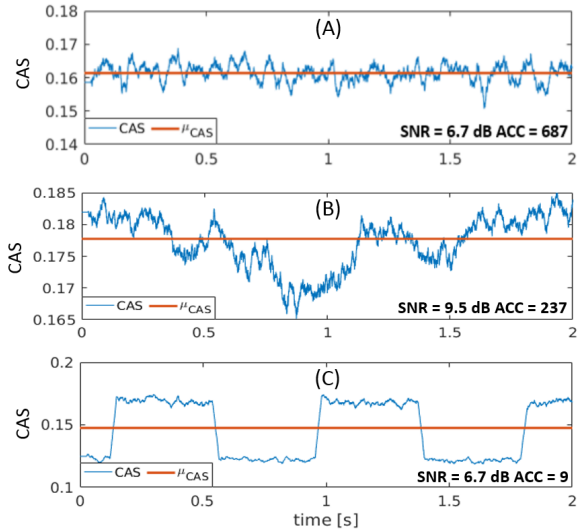

Figure 3: CAS and ACC for a frame transmitted through 'undisturbed' channel (A), 'fading' channel (B) and 'interference' channel (C).

4 Conclusion

The use of USRP in combination with GnuRadio and Matlab provides reliable, real world signals for designing low complexity CSI to feed a realistic channel state classifier. Our work will aid to develop energy saving strategies for lifetime enhancement of radiofrequency systems for LPWA networks.

References

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