Thesis subject CNES 2018

Interference management applied to full-duplex transmissions for nano-satellites: new waveform and joint detection.

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Context

In telecommunication systems, a duplex transmission is usually operated by doubling the physical resources used to separate the uplink and the downlink (frequency, time or polarization duplex for example). This is denoted as a half-duplex transmission. This separation is all the more required as the power gap between the sent signal and the received signal is high (usually of roughly 110 dB, and possibly over 130 dB for satellite communications [1]).

However, higher spectral efficiencies can be obtained by not doubling the physical resource. In that case, some processing has to be performed to remove the interference created by the transmitted signal over the received signal: this transmission technique is named full-duplex. For example in the Doubletalk technique [2,3], the knowledge of the sent signal is subtracted from the received signal (adaptive echo cancellation). This pre-processing enables to reject the interference induced by its own sent signal over the received signal by about 28 to 35 dB [3]. This rejection level is sufficient for a full-duplex communication for a ground station equipped with 2 directive antennas, providing that there radiation pattern do not overlap (antennas decoupling).

Considering nanosatellites [4] (e.g. CubeSat), antennas decoupling is not feasible due to lack of space. Analog techniques [5,6] can then be used as a complement to the adaptative echo canceler but the overall rejection level remains too low..

Subject

In this thesis, a focus on the improvement of digital techniques toward interference processing is proposed, not by interference rejection but rather by using the inherent temporal diversity between the two interfering signals: despite having the same waveform, they carry different and independent information yielding different evolution in time (phases, symbols, timing or frequency offsets, etc.) which can be used to separate them.

In the first part of the thesis, half-duplex transmissions will be considered. Research work will first start on a waveform design that ensures this separability by considering two aspects: to improve the

detection performance of either the transmitted signal, or the received signal. To put it differently, the first case would be the design of a waveform which is robust to the interference created by the received own signal, the second case would be the design of a waveform that would reduce the interference created on the received signal when forwarded by the relay.
Then research work will be conducted on the robustness evaluation of the chosen waveform against a different interfering signal acting as a scrambler, and then by studying the joint detection of the two signals in under-determined conditions (interception). In the second part of the thesis, the results obtained will be applied to full-duplex transmissions.

References

[1] Eugene Grayver, Ryan Keating, Adam Parower, "Feasibility of Full Duplex Communications for LEO Satellite ", IEEE Aerospace Conference, Mars 2015.

[2] "Self-interference cancellation for relayed communication networks", US Patent US006011952A – January 2000 – Viasat, Inc.

[3] "Optimizing Satellite Communications Using DoubleTalk® Carrier-in-Carrier®& CDM-625 Advanced Satellite Modem",White Paper Comtech EF Data Corporation – Dec. 2010.

[4] "CNES and Nexeya invest to develop nanosatellite industry", press release, CNES, 18 may 2017, available on https://presse.cnes.fr/en/cnes-and-nexeya-invest-develop-nanosatellite-industry

[5] M. Jain, et al., "Practical, real-time, full duplex wireless", Proc. International Conference on Mobile Computing and Networking Mobicom 2011, Las Vegas, NV, USA, September 2011- pp. 301-312.

[6] D. Bharadia, E. McMilin, and S. Katti, "Full duplex radios," Proc. SIGCOMM'13, Hong-Kong, August 2013.