Estimating and Tracking Wireless Channels Under Frequency Offsets

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Oscillator inaccuracies in transmitter and receiver pairs inevitably result in carrier and sampling frequency offsets, and oscillators generally exhibit long-term drifting and short-term fluctuations that make these frequency offsets time-varying. To make matters worse, in wireless propagation these frequency offsets can be further aggravated by the Doppler effect. A general two-node system highlighting the source of these impairments is illustrated in Fig. 1. In many cases, time-varying frequency offsets are harmful or even destructive to the performance of wireless systems. Most notably, frequency offsets negatively affect practical applications like orthogonal multicarrier communication systems, bistatic radar setups, interference alignment within wireless networks, and underwater acoustic communications. They are also the central challenge to known-interference cancellation, which is often considered achievable in theory, but has seen only limited demonstration in practice.

Compensating the frequency offsets so as to suppress their negative effects requires the offsets to be estimated and, due to their time-varying nature, continuously tracked. This must of course be done simultaneously to estimating and tracking the wireless channel itself too. In cases where the latter alone is sufficient, conventional adaptive filters have proven especially popular solutions due to their robustness and simplicity. Practical use of adaptive filters is also supported by their well-understood behaviour in steady and tracking states. However, frequency offsets tend to compromise the performance of classical adaptive filters [1]. As such, it is an appealing challenge to design a robust-yet-simple adaptive filter with analytically well-understood behaviour that can jointly and explicitly estimate and track both the wireless channel and frequency offsets. Successfully solving that challenge could improve the performance or even bridge the gap from theoretically desirable to practically viable of the above-listed applications.

[1] R. Nabil Yousef and H. Ali Sayed, "Ability of adaptive filters to track carrier offsets and channel nonstationarities," IEEE Transactions on Signal Processing, volume 50, no. 7 (2002): 1533-1544.

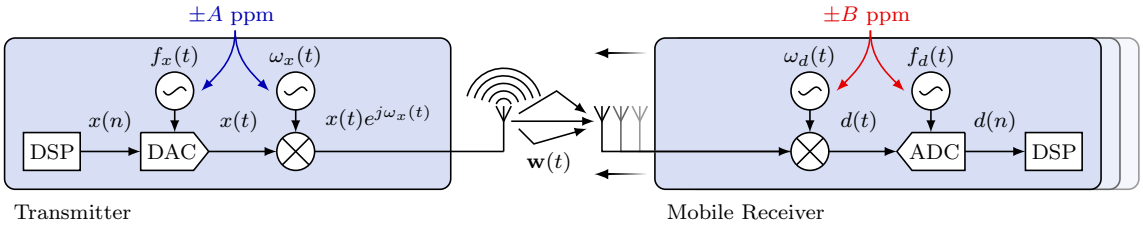

Figure 1: Two-node system model highlighting the sources of frequency offset in wireless systems.