Performance Evaluation of iMPAs for Fast Acquisition of Spreading Codes with Application to Satellite Positioning

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Abstract

Fast acquisition of long spreading codes in spread-spectrum (SS) signals is an open problem in military and commercial communications as well as in positioning systems. The standard detection algorithms are: full parallel search, simple serial search, and hybrid search. The first method implements a *maximum-likelihood* (ML) estimation, so it requires a fully parallel architecture. Therefore, it provides a fast detection with a high implementation complexity. The simpler serial search has lower complexity, but its acquisition time for long sequences is prohibitively long. The hybrid search is a trade-off between these two methods.

In this context, recent papers have presented a new technique to acquire *linear feedback shift register* (LSFR) sequences (such as *m*-sequences and Gold codes) based on running an *iterative message passing algorithms* (iMPA) on graphical models with cycles. Instead of correlating the incoming signal with a local replica, this algorithm uses all the information provided by received signals as messages to be exchanged within such graphs (designed exploiting the LFSR generating polynomial structure), thus approximating the ML method. This results a sub-optimal algorithm, that searches all code phases in parallel with a complexity lower than that of a fully parallel implementation, and with an acquisition time that is shorter than that of a simple serial algorithm.

The aim of this work is the evaluation of the mean and the variance of the acquisition time of iMPA detectors in coherent SS communication systems, exploiting Markov chain theory. More specifically, we firstly describe the iMPA detector architecture, and we subsequently introduce the standard procedure that an acquisition unit should follow to correctly acquire an incoming SS signal. Then, we build the Markov flow graph of the detector, that is used to evaluate the *moment generating function* (MGF) of its acquisition time. From the MGF we can easily compute the mean and the variance of the acquisition time, that is also compared to the corresponding performance of the standard detection techniques (fully parallel and serial). Our analysis is also completed by comparing all these algorithms in terms of computational complexity and (missed/wrong) acquisition probability as derived by simulation.

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Keywords: iterative detection; message passing algorithms; spread-spectrum systems; detection algorithms; decoding algorithms.