# Chapter 11
# Further Improvements of the Watermarking Scheme

In the previous chapter, we have proposed a watermarking scheme that embeds watermarks into the host signal where the audio power spectrum is below the masking threshold. This scheme, although proven to be better than the PE psychoacoustic model based watermarking scheme, still has room for further improvements. In this section, we will propose an enhanced watermarking scheme that not only embeds the watermark into the below masking threshold area, but also takes advantage the HAS properties and inserts the watermark into the audible spectrum areas and still keep the introduced distortion imperceptible.

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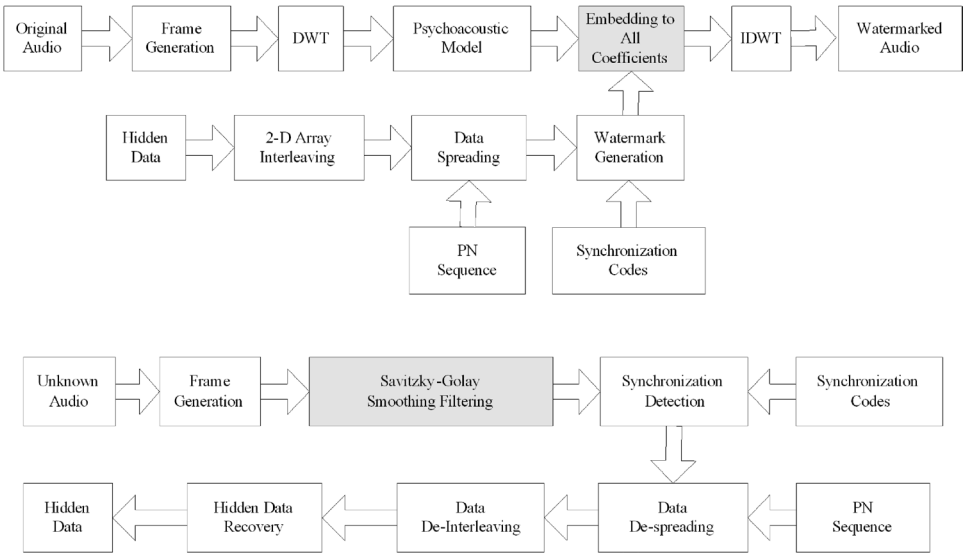
*Figure 1. New proposed watermarking system: encoder (top) and decoder (bottom)*




## 11.1 DIAGRAM OF PROPOSED ENHANCED WATERMARK SYSTEM

The diagram of the enhanced watermarking system (encoder and decoder) is illustrated in Figure 1.

Comparing Figure 1 in the current chapter with Figure 1 in chapter 10, we can see that the differences between the enhanced system and the previously proposed one are:

a. For the enhanced encoder, the watermarks are embedded into all wavelet coefficients, regardless of the host signal wavelet power spectrum distribution. In the previously proposed encoder, however, the watermarks are only embedded to the area where the host signal wavelet power spectrum is below the masking thresholds.
b. For the enhanced decoder, the psychoacoustic model is dropped off and replaced by a Savitzky-Golay smoothing filter (William et al., 1992), which is used to de-correlate the host signal and the watermark and decrease the interference from the host signal. Since no psychoacoustic model is needed, the enhanced decoder performs much faster than the previously introduced due to the huge amount saved from the reduction of the masking thresholds estimation.