SBR explained: White paper

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1 Introduction

Low bitrate audio coding is an enabling technology for a number of applications like digital radio, Internet streaming (web radio) and mobile multimedia applications.

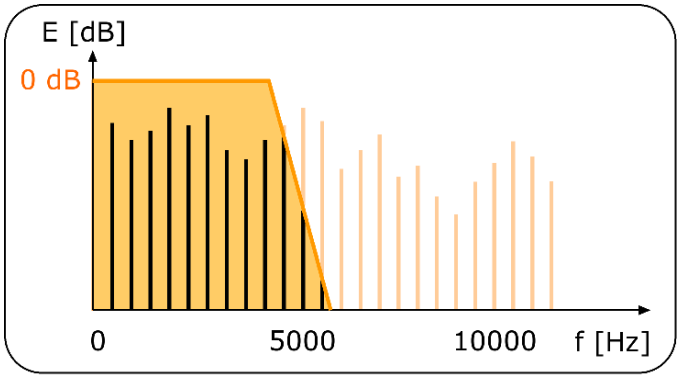
The limited overall bandwidth available for a digital radio system (terrestrial or satellite based) makes it desirable to use a low bitrate per channel in order to create an attractive portfolio of programs for the listener. Therefore, system designers have to use highly efficient perceptual audio codecs (like mp3 or AAC) at low bitrates.

In Internet streaming applications, the connection bandwidth that can be established between the web radio server and the listener's client application depends on the listener's connection to the Internet. In most cases today, people use analogue modems or ISDN lines with a fairly limited datarate, lower than the rate which would be desirable to produce an appealing audio quality by means of conventional perceptual audio codecs. And even if consumers connect to the Internet through high bandwidth connections such as xDSL, the ever-present congestion on the Internet limits the connection bitrate that can be used in a stable manner over a longer time period.

In mobile communications, the situation is similar to the digital radio scenario. Since the overall bandwidth available for all services in a certain geographic area (a network cell) is limited, the system operator has to take measures to allow as many users as possible in that network cell to access mobile communication services in parallel. It is evident that for commercial reasons, the network operators have to ensure that they use their available spectrum as efficiently as possible by means of highly efficient speech and audio codecs. Considering the impact that the advent of multimedia services has on the datarate demands in mobile communication systems, it becomes immediately apparent that even with UMTS, cellular networks will have to use perceptual codecs at a fairly low datarate.

2 The technical challenge

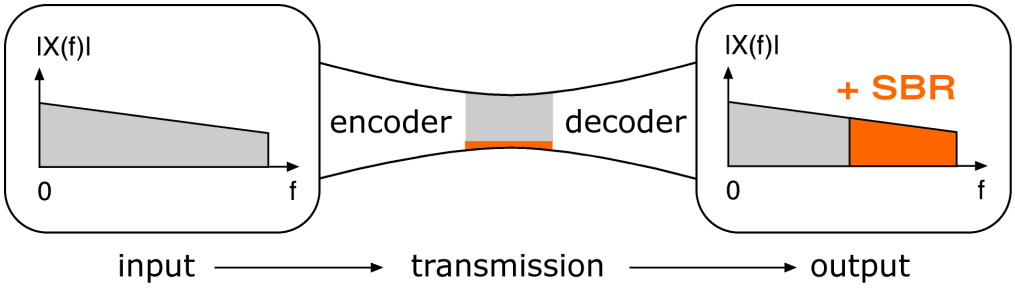
Using perceptual codecs at low bitrates, however, is not without it's downside. State-of-the-art perceptual audio codecs achieve "CD-quality" or "transparent" audio quality at a bitrate of approximately 128 kbps (~ 12:1 compression). Below 128 kbps, the perceived audio quality of most of these codecs begins to degrade significantly. The codecs either start to reduce the audio bandwidth and to modify the stereo image, or they introduce annoying coding artifacts resulting from a shortage of bits in the attempt to represent the complete audio bandwidth. Both ways of modifying the perceived sound can be considered unacceptable above a certain level. At 64 kbps for instance, mp3 would either offer an audio bandwidth of only ~ 10 kHz or introduce a fair amount of coding artifacts. Each of these factors severely affects the listening experience.



example of band-limiting of a typical signal

3 The technical solution

SBR (Spectral Band Replication) is a new audio coding enhancement tool. It offers the possibility to improve the performance of low bitrate audio and speech codecs by either increasing audio bandwidth at a given bitrate or by improving coding efficiency at a given quality level. SBR can increase the limited audio bandwidth that a conventional perceptual codec offers at low bitrates, so that it equals or exceeds analogue FM audio bandwidth (15 kHz).



SBR can also improve the performance of narrow-band speech codecs, offering the broadcaster speech-only channels with 12 kHz audio bandwidth used for example in multilingual broadcasting. As most speech codecs are

very bandlimited, SBR is important not only for improving speech quality, but also for improving speech intelligibility and speech comprehension. SBR is mainly a post-process, although some pre-processing is performed in the encoder in order to guide the decoding process.

From a technical point of view, SBR is a new method for highly efficient coding of high frequencies in audio compression algorithms. When used in conjunction with SBR, the underlying coder is only responsible for transmitting the lower part of the spectrum. The higher frequencies are generated by the SBR decoder, which is mainly a post-process following the conventional waveform decoder. Instead of transmitting the spectrum, SBR reconstructs the higher frequencies in the decoder based on an analysis of the lower frequencies transmitted in the underlying coder. To ensure an accurate reconstruction, some guidance information is transmitted in the encoded bitstream at a very low datarate.

The reconstruction is efficient for harmonic as well as for noise-like components and allows for proper shaping in the time domain as well as in the frequency domain. As a result, SBR allows full bandwidth audio coding at very low data rates, thus offering a significantly increased compression efficiency compared to the core coder.

4 The Performance

SBR can enhance the efficiency of perceptual audio codecs by ~ 30 % (even more in certain configurations) in the medium to low bitrate range. The exact level of improvement that SBR can offer also depends on the underlying codec. For instance, using SBR in conjunction with mp3 (see below under mp3PRO) we can achieve a quality at 64 kbps stereo that compares to conventional mp3 at a bitrate of > 100 kbps stereo. SBR can be used with mono as well as stereo material and could also be applied to 5.1 channel audio.

SBR offers maximum efficiency in the bitrate range where the underlying codec itself is able to encode audio signals with an acceptable level of coding artifacts at a limited audio bandwidth.

5 Applications

mp3PRO: mp3PRO is the combination of mp3 and SBR in a backwards compatible way.
Through carefully designed compatibility features, mp3PRO can be easily introduced into the existing mp3 market. Conventional mp3 players can still render a useful output from an mp3PRO bitstream and mp3PRO players are of course fully capable of playing legacy mp3 streams.

The performance of mp3PRO is significantly higher than that of mp3. mp3PRO at 64 kbps performs better than mp3 at 96 kbps, offering the user a convenient way to drastically improve the storage efficiency of his portable player. mp3PRO will also be able to improve the fidelity at 128 kbps, allowing true CD-quality storage and replay in the home stereo environment. At the lower bitrates used for streaming applications today, mp3PRO will help to increase the audio bandwidth of the compressed signal, giving it a substantial subjective quality boost over current streaming formats.
mp3PRO is available in software today and will be available as DSP code around Summer 2001. It is available for licensing through Thomson Multimedia (info@mp3licensing.com).

DRM: Digital Radio Mondiale (DRM) is a worldwide industry consortium that got together to define a global standard for digital radio in the short- and medium-wave frequencies. These frequencies are currently used for low-quality, wide-range radio transmissions, mostly by large global broadcasters like BBC World Service, Radio France International, Voice of America and Deutsche Welle.
The transmission channel characteristics and the current channel spacing (which will be maintained in the digital system for reasons of coexistence in the transition period) do not allow a very high datarate, making this system an ideal candidate for the use of SBR.
Within the DRM system, SBR will be used in connection with AAC.

6 More Information

More information is available on request via Coding Technologies.

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