apt-X Lossless

a technical white paper

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INTRODUCTION

There exist numerous schemes – the results of development activity over many years in both the academic and commercial fields, and within the wider open source community – for the so-called lossless compression of digital audio. These schemes, which include, for example, **Apple Lossless** [1], Free Lossless Audio Codec (aka **FLAC**) [2], and recently, **mp3HD** [3], are typically applied to gain useful economies through the data reduction ("compression") in the bulk size of archived audio files (mainly music, but also speech) held in storage on, usually, a computer hard-disk drive (HDD), dedicated file server, or on solid-state memory device (e.g., Flash memory) and other portable mass-storage systems, including read/writeable optical media (CD-ROM, DVD, DVD-HD, Blue-ray, etc). These various formats are described and compared elsewhere [4].

This technology white paper introduces the reader to an entirely new scheme for lossless audio compression called **apt-X Lossless.** This scheme has been conceived, designed and developed by APTX, a pioneering audio processing technology company, the commercial originator of the apt-X low-latency audio codec, and a venture-funded, private company with a long and profitable association with both the broadcast industry and the studio post production business [5]. Briefly and simply, by employing dynamic adaptation techniques to a greater and more intelligent extent than conventional schemes, **apt-X Lossless**, offers significant benefits over existing lossless audio codecs, and attains better coding scalability and run-time trade-offs as a result. These benefits are of considerable importance to strongly emerging applications for high-definition forms of digital entertainment, especially those deployed in the wirelessly networked, broadband home, and those portable systems being developed for consumers on the move.

The applications of **apt-X Lossless** are not limited to broadcast digital TV and radio, but encompass multi-channel/multi-program audio for high-def video-on-demand, and new forms of immersive, multimedia entertainments, such as massively multi-player on-line games. APTX positions the **apt-X Lossless** solutions as the organic continuation of a series of low-latency, predictive audio codecs sharing the apt-X branding, starting with Standard apt-X, Enhanced apt-X and apt-X Live.

apt-X Lossless will be joined by another compression scheme – **apt-X Scalable** – a versatile architecture with universal application across different processor platforms, variegated data bandwidth conditions, energy budget, sonic fidelity and time-latency.

TECHNOLOGY OVERVIEW AND FEATURES

apt-X Lossless is an audio codec developed by APTX (APT Licensing Ltd.) for the lossless compression of digital audio (including music, natural and synthetic speech, etc). A 16-bit, 48 kHz stereo audio stream processed using **apt-X Lossless** typically compresses to about 55% of its original average bit-rate, even for real-time audio streaming where low coding latency, low computational complexity and high tolerance to communication errors is important. Short-term compressed data rates for this type of stream typically fluctuate in the range of 500-900 kbps.

Note: the degree of compression achievable with purely lossless coding is heavily dependent on the nature of the audio material, hence average compression rates are quoted with respect to a large test suite of varied audio tracks, including music of various genres and speech in various languages.

apt-X Lossless supports high-definition audio up to 96 kHz sampling rates and sample resolutions up to 24 bits. The codec optionally permits a "hybrid" coding scheme for applications where average and/or peak compressed data rates must be capped at a constrained level. This involves the dynamic application of a mild form of lossy coding only for the short sections of audio where completely lossless coding cannot respect the bandwidth constraints. Even for the short periods whilst the lossy coding is active, the audio quality is maintained at a high level, retaining audio frequencies up to 20 kHz and a dynamic range of at least 120 dB for high-definition audio.

Coding latency is another scalable parameter within **apt-X Lossless** and can be dynamically traded against other parameters such as levels of compression and computational complexity. The latency of the **apt-X Lossless** codec can be scaled to as low as 1 ms for 48 kHz sampled audio, depending on the settings of other configurable parameters. **apt-X Lossless** performs particularly well against other lossless codecs when the coding latency is constrained to be small, such as 5 ms or less, making it particularly appropriate for delay-sensitive interactive audio applications.

Due to their simpler signal processing functions, many lossless codecs possess a low computational complexity compared to well-known lossy codecs such as MP3 and AAC. This is particularly important for deeply-embedded audio applications running on low-power mobile devices. **apt-X Lossless** promotes low computational complexity in a novel way by supporting dynamic adaptation of the signal processing functions used to code each short segment of audio in such a way that the computational complexity of the selected functions is minimized whilst respecting other configured constraints, such as levels of compression and coding delay. Depending on the settings of other scalable parameters, **apt-X Lossless** can encode a 48 kHz 16-bit stereo audio stream using only 10 MIPS on a modern RISC processor with signal processing extensions. The corresponding decoder represents only 6 MIPS on the same platform.

Note: that these figures do not account for any additional processing overhead required to incorporate apt-X Lossless data within the packet format of any particular communications scheme used to stream the audio.

Special synchronization data is incorporated into the compressed format at configurable rates to allow rapid decoder resynchronization in the event of data corruption or loss over communications links where Quality of Service (QoS) can vary rapidly. Depending on the settings of other configurable parameters, decoder resynchronization can occur in time periods as short as 1-2 ms. User metadata can optionally be incorporated into the compressed format at configurable rates. It should be noted that the syntax of the **apt-X Lossless** format is not directly compatible with other lossless coding formats and no transcoding, apart from full decoding and re-encoding, is currently possible.

BENEFITS

- Highly scalable and dynamically adaptive coding mechanism
- High-performance lossless compression
- Broadcast-grade audio
- Low coding delay
- Low computational complexity, run-time overhead and device power consumption
- Hybrid lossy coding for communications links with stringent bandwidth constraints
- Easily portable across multiple hardware and software platforms

APPLICATIONS

- Wireless audio peripherals for media players
- Digital wireless microphones
- Music storage and archiving
- Audio consoles
- Digital audio routers
- Broadcast audio distribution between production, network and transmission sites

MARKETS

- Consumer audio devices
- Professional audio equipment
- Broadcast audio distribution

PLATFORMS

The **apt-X Lossless** technology is implemented as C and C++ code and has been verified on the following processors:

- x86
- ARM 9E
- ARM Cortex M3
- Texas Instruments C64xx
- *other processor cores and DSPs to be verified and announced*

GENERAL THEORY OF OPERATION

The conceptual architecture of the **apt-X Lossless** encoder and decoder is depicted in Figure 1.

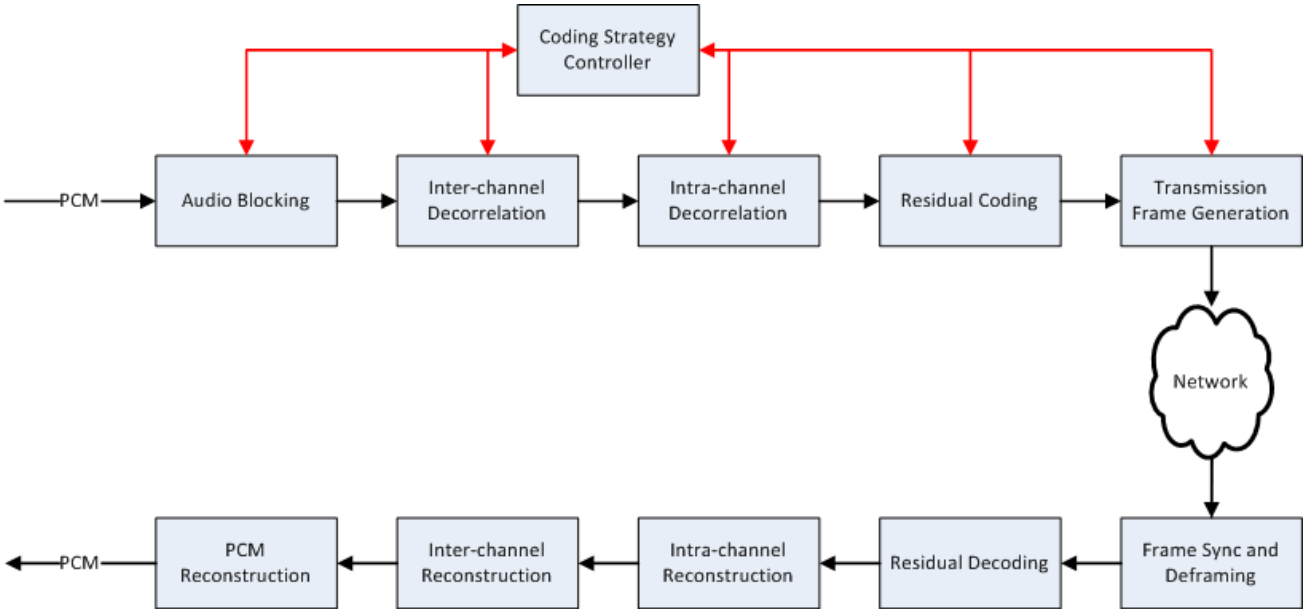

Figure 1: apt-X Lossless Conceptual Architecture

At the highest conceptual level, apt-X Lossless has a very traditional structure for a lossless audio codec. Audio, in the form of PCM samples, is initially gathered into blocks of samples. Compression is achieved by successively removing data correlation across audio channels and within each audio channel. The resulting residual data is further encoded via entropy coding techniques and packed into transmission frames, together with any necessary user metadata, decoder synchronization data and error control/correction data. After transmission across some form of network, or alternatively playback from a compressed file format, the decoder acquires, monitors and, when necessary, reacquires frame synchronization with the aid of the embedded synchronization and error control information. Valid received frames then undergo entropy decoding followed by intra- and inter-channel reconstruction processes which reverse the peer functionality in the encoder.

A simple, yet relevant, demonstration of the flexible performance of **apt-X Lossless** is shown by the graph in Figure 2. For this example, **apt-X Lossless** is used to process a number of audio files from the EBU SQAM test suite. The audio in each file contains 16-bit values samples at 44.1 kHz. Crucially, the scalable parameters of apt-X Lossless are set to enforce a challenging codec latency constraint of 2 ms. The graph measures the levels of compression achieved by **apt-X Lossless** against the FLAC codec with comparable performance settings.

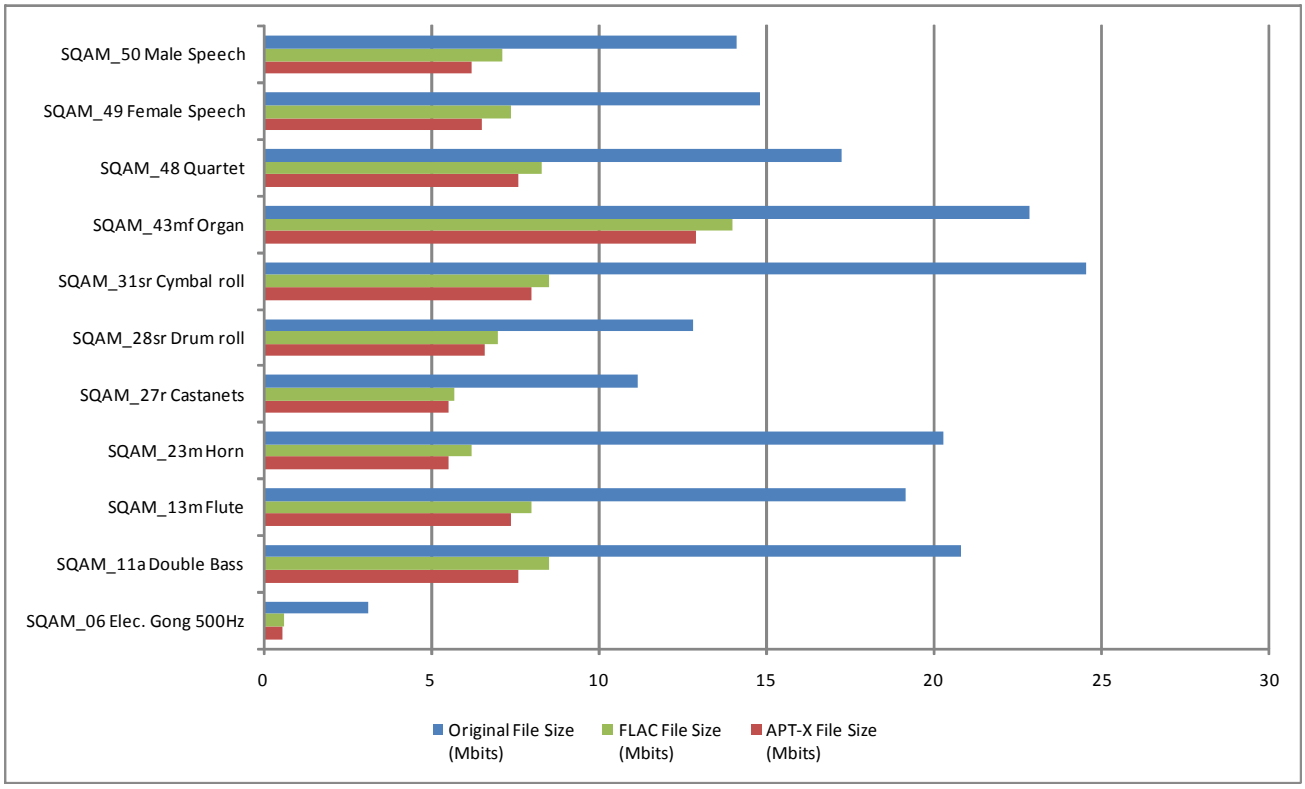

Figure 2 : apt-X Lossless Performance Example

CONCLUSION

apt-X Lossless is a lossless audio coding technology that fulfils a market need for more scalable and controllable performance across the key audio codec metrics of data-rate reduction, delay, robustness and computational complexity. It achieves this by adopting fine-grained dynamic adaptation of the coding technique for successive segments of audio and composing all necessary coding operations using automatically-selected combinations from a large palette of very simple primitive signal processing functions. The resulting flexibility and performance makes apt-X Lossless the preferred lossless audio codec for a wide variety of applications, particularly real-time streaming over wireless networks.

-ends-

REFERENCES

[1] **Apple Lossless** – Wikipedia: http://en.wikipedia.org/wiki/Apple_Lossless

[2] **FLAC**: http://flac.sourceforge.net

[3] **mp3HD**: http://www.all4mp3.com/Learn_mp3_hd_1.aspx

[4] **Hydrogen Audio** – Lossless comparison:
http://wiki.hydrogenaudio.org/index.php?title=Lossless_comparison

[5] **APTX** – apt-X Lossless: http://www.aptx.com

MORE INFORMATION

More information about **apt-X Lossless** and other **apt-X®** series audio codecs, including comprehensive technical data and specimen commercial licensing documentation, is available from the appropriate contacts given or send a request e-mail to *licensing@aptx.com*

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