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**ANALOG OUTPUT-STAGE FINGERPRINTING
IN DMAT/SDML**

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Abstract

Most of the current audio media intellectual property rights protection schemes suffer from one essential drawback: the high quality of any lineout-linein connection, i.e. the ability to record directly from the “speaker” so to speak, with a surprisingly minimal distortion¹.

Thus, no-matter what prevention schemes are deployed, including copy-bits, zoning, online secure distribution etc, once the analog stream hits the speaker it becomes a potential seed for property rights violations.

Fingerprinting distribution media is an effective but not cost-efficient mean of enabling trace-back of intellectual property theft. Cost-wise it is practically prohibitive to fingerprint each single sold CD prior to stamping. Robust audio fingerprints require extensive data manipulation with access to the analog domain and is certainly not deployable in the CD market in production quantity today.

Online distribution services could make use of fingerprinting when content is accessed through a personalized authenticated entry-point. This makes traceback easy and, technically, its cost-wise more efficient than in the CD market. The limitation of this scheme lies in linking music distribution with the requirement to own a high speed internet-connected computer. This basically limits the distribution network and, we believe, is not a feasible large-scale solution for the near to medium future, especially in emerging markets where ballancing the costs of buying a cheap CD vs. buying an expensive computer is not satisfactory.

We propose a solution in which content is distributed on regular media (e.g. CD), but is “play-able” only on DMAT-enabled devices. Once this link is satisfied the next step involves modifying the devices to include device-identifying fingerprinting technology in the analog stream domain (see figure).

This technology and the associated fingerprinting scheme have to satisfy certain requirements.

1. Embedded fingerprinting keys and algorithms need to be update-able. This could be implemented through special portions of the distribution medium, readable only by SDMI devices, where the new update-code is stored encrypted or in some other non-obvious form and then loaded and “burned” in the device’s own EPROM.

¹Tests performed in transferring a perfect sinusoidal of 3000Hz through a \$19.95 PCI sound card out-in channels resulted in less than .02% distortion in the copied data.

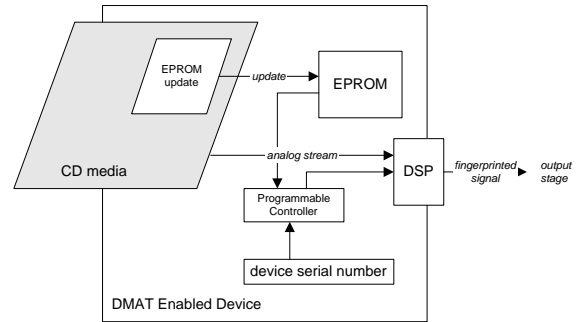


Figure 1: Analog output-stage fingerprinting in DMAT-enabled device.

2. The analog domain marks need to be fairly resilient and resist common compression algorithms and transformations (e.g. MP3, WMA, MP3pro) up to any acceptable quality level for which the content is still market-able.

Note: Another idea would be to rely on a controllable, adaptive output stage that allows the marking scheme to provide higher resilience (i.e. implicitly higher distortion levels) for lower guaranteed device-output fidelity.

3. Given any resulting fingerprinted content, it should provide enough information to track and identify the originator device. In this scenario, unique device-id’s (e.g. similar to the case of network cards) need to be deployed.

Designing an appropriate fingerprinting algorithm and the required special purpose hardware is not trivial but well within the realm of current mass-market technologies.

At the software level, analog variations of echo-hiding techniques and others should maybe be investigated. In what hardware is concerned, a set of general purpose low-frequency programmable DSP processors together with an associated EPROM and controller might be an appropriate starting point.

Implementation and algorithmic details aside, the novelty of the proposed scheme lies in placing parts of the protection mechanism perspective to the distribution point (e.g. device). This aims at bringing intellectual property protection closer to becoming actually effective.