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A method for storing audio-centered information with a multi-level Table-of-Contents (TOC) mechanism with one Master-TOC and Sub-TOCs for various audio formats, a device for use with such mechanism and a unitary storage medium containing such mechanism.

The invention relates to a method as recited in the preamble of Claim 1.

Digital audio storage on unitary media such as disc or tape is at present widespread. In case of actual sub-division of the audio into multiple sub-items, the providing of a **Table-of-Contents** (TOC) allows to access the information in a relatively fast manner. Generally, a TOC specifies at least **what** has been stored and **where** it has been stored. However, audio is being also defined according to multiple standardized audio formats, such as two-channel stereo, multiple (5-6) channel audio such as for use in surround sound applications, and possibly others. An audio provider may wish to combine various different such formats on a single medium such as an optical disc, and in consequence, a user would want to be able to access various audio items in a fast and easy manner.

In consequence, amongst other things, it is an object of the invention to allow the audio management system to discriminate between the various formats, and to navigate among the various items of only a single format, so that it will not be necessary to change an actual decoder strategy. Now therefore, according to one of its aspects the invention is characterized according to the characterizing part of Claim 1.

The invention also relates to a unitary storage medium produced by the method, and to a reader or player arranged for interfacing with such storage medium. One or more of the audio formats could effectively be a dummy, but for reasons of standardizing, the multilevel TOC arrangement is then also adopted. Further advantageous aspects of the invention are recited in dependent Claims.

These and further aspects and advantages of the invention will be discussed more in detail hereinafter with reference to the disclosure of preferred embodiments, and in particular with reference to the appended Figures that show:

Figures 1a, 1b a record carrier,



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Figure 2 a playback device,

5 Figure 3 a recording device,

Figure 4, a file system for use with the invention;

Figure 5, a first storage arrangement for the invention;

Figure 6, a second storage arrangement for the invention.

Table 1 specifies a Master_TOC Syntax;

10 Table 2 specifies a Master_TOC_O Syntax;

Table 3 specifies a Disc_Info Syntax.

Figure 1a shows a disc-shaped record carrier 11 with track 19 and central hole 10. Track 19 is arranged in a spiral pattern of turns forming substantially parallel tracks on an information layer. The carrier may be an optical disc with a recordable or a prerecorded information layer. Examples of a recordable disc are CD-R, CD-RW, and DVD-RAM, whereas audio CD is a prerecorded disc. Prerecorded discs can be manufactured by first recording a master disc and later pressing consumer discs. Track 19 on the recordable record carrier is indicated by a providing a pre-embossed track structure during manufacture of the blank record carrier. The track may be configured as a pregroove 14 to enable a read/write head to follow the track 19 during scanning. The information is recorded on the information layer by optically detectable marks along the track, e.g. pits and lands.

Figure 1b is a cross-section along the line b-b of a recordable record carrier 11, wherein transparent substrate 15 carries recording layer 16 and protective layer 17. The pregroove 14 may be implemented as an indentation, an elevation, or as a material property deviating from its surroundings.

For user convenience, the audio information on the record carrier has been subdivided into items, which usually have a duration of a few minutes e.g. songs on an album or movements of a symphony. Usually the record carrier also contains access information for identifying the items, such as in a so-called Table Of Contents (TOC), or included in a file system like ISO 9660 for CD-ROM. The access information may include playing time and start address for each item, and also further information like a song title.

The audio information is recorded in digital representation after analog to digital (A/D) conversion. Examples of A/D conversion are PCM 16-bit per sample at 44.1

kHz known from CD audio and 1 bit Sigma Delta modulation at a high oversampling rate e.g. 64
 5 x F_s called bitstream. The latter method represents a high quality encoding method, with a choice
 between high quality decoding and low quality decoding, the latter allowing a simpler decoding
 circuit. Reference is made in this respect to documents D5 and D6 infra. After A/D conversion,
 digital audio is compressed to variable bitrate audio data for recording on the information layer.
 The compressed audio data is read from the record carrier at such a speed, that after
 10 decompression substantially the original timescale will be restored when reproducing the audio
 information continuously. Hence the compressed data must be retrieved from the record carrier at
 a speed dependent on the varying bitrate. The data is retrieved from the record carrier at so-called
 transfer speed, i.e. the speed of transferring data bytes from the record carrier to a de-compressor.
 The record carrier may have uniform spatial data density, which gives the highest data storage
 15 capacity per unit of area. In such system the transfer speed is proportional to the relative linear
 speed between the medium and the read/write head. If before the de-compressor a buffer has
 been provided, actual transfer speed is the speed before that buffer.

Figure 2 shows a playback apparatus according to the invention for reading a
 record carrier 11 of the type shown in Figure 1. The device has drive means 21 for rotating record
 20 carrier 11 and a read head 22 for scanning the record carrier track. Positioning means effect 25
 coarse radial positioning of read head 22. The read head comprises a known optical system with
 a radiation source for generating a beam 24 that is guided through optical elements and focused
 to spot 23 on an information layer track. The read head further comprises a focusing actuator for
 moving the focus of the radiation 24 along the optical axis of the beam and a tracking actuator
 25 for fine positioning of spot 23 in a radial direction on the centre of the track. The tracking
 actuator may comprise coils for moving an optical element or may be arranged for changing the
 angle of a reflecting element. The radiation reflected by the information layer is detected by a
 known detector in the read head 22, e.g. a four-quadrant diode, to generate a read signal and
 further detector signals including a tracking error and focusing error signals for the tracking and
 30 focusing actuators, respectively. The read signal is processed by a reading means 27 to retrieve
 the data, which reading means are of a usual type for example comprising a channel decoder and
 an error corrector. The retrieved data is passed to a data selection means 28, to select the
 compressed audio data for passing on to buffer 29.

The selection is based on data type indicators also recorded on the record carrier, e.g. headers⁴
 in a framed format. From buffer 29, the compressed audio data are passed on to de-compressor
 31 as signal 30. This signal may also be outputted to an external de-compressor. De-compressor
 5 31 decodes the compressed audio data to reproduce the original audio information on output 32.
 The de-compressor may be fitted in a stand-alone high quality audio D/A convertor 33.
 Alternatively, the buffer may be positioned before the data selections means. The buffer 29 may
 be positioned in a separate housing or may be combined with a buffer in the decompressor. The
 device furthermore has a control unit 20 for receiving control commands from a user or from a
 10 host computer not shown, that via control lines 26 such as a system bus is connected to drive
 means 21, positioning means 25, reading means 27 and data selection means 28, and possibly
 also to buffer 29 for buffer filling level control. To this end, the control unit 20 may comprise
 control circuitry, such as a microprocessor, a program memory and control gates, for performing
 the procedures described below. Control unit 20 may be implemented as a logic circuit state
 15 machine.

The art of audio compression and de-compression is known. Audio may be
 compressed after digitizing by analyzing the correlation in the signal, and producing parameters
 for fragments of a specified size. During de-compression the inverse process reconstructs the
 original signal. If the original digitized signal is reconstructed exactly, the (de-)compression is
 20 lossless, whereas lossy (de-)compression will not reproduce certain details of the original signal
 which however are substantially undetectable by the human ear or eye. Most known systems for
 audio and video, such as DCC or MPEG, use lossy compression, whereas lossless compression is
 used for storing computer data. Examples of audio compression and decompression can be found
 in D2, D3 and D4 hereinafter, of which in particular the lossless compression from D2 is suitable
 25 for high quality audio.

According to the invention, data selection means 28 are arranged to retrieve
 from the read data certain control information. The data selection means 28 are also arranged to
 discard any stuffing data, that had been added during recording. When the control unit 20 is
 commanded to reproduce an item of audio from the record carrier, the positioning means 25 are
 30 controlled to position the reading head on the portion of the track containing the TOC. The
 starting address for that item will then be retrieved from the TOC via the data selection means
 28. Alternatively the contents of the TOC may be read only once and stored in a memory when
 the disc is inserted in the apparatus. For reproducing the item the drive means

21 are controlled to rotate the record carrier at an appropriate rotary velocity, to be derived from timing indications stored with the audio. The radial position of the item can be calculated as based on the starting address, because the record carrier density parameters like track pitch and bit length, are predetermined and known to the playback device, usually from a standard. Subsequently the rotation rate can be derived from the bitrate and the radial position.

To provide continuous reproduction without buffer underflow or overflow the transfer speed is coupled to the reproduction speed of the D/A converter, i.e. to the bitrate after decompression. To this end the apparatus may comprise a reference frequency source for controlling the decompressor and the rotation rate may be set in dependence on the reference frequency and the speed profile. Alternatively or additionally the rotation rate may be adjusted using the average filling level of buffer 29, e.g. decreasing the rotation rate when the buffer is more than 50% full on average.

Figure 3 shows a recording device according to the invention for writing information on a (re)writable record carrier 11. During a writing operation, marks representing the information are formed on the record carrier. The marks may be in any optically readable form, e.g. in the form of areas whose reflection coefficient differs from their surroundings, by recording in materials such as dye, alloy or phase change, or in the form of areas with a direction of magnetization different from their surroundings when recording in magneto-optical material. Writing and reading of information for recording on optical disks and usable rules for formatting, error correcting and channel coding, are well-known, e.g. from the CD system. Marks may be formed through a spot 23 generated on the recording layer via a beam 24 of electromagnetic radiation, usually from a laser diode. The recording device comprises similar basic elements as described with reference to Figure 2, i.e. a control unit 20, drive means 21 and positioning means 25, but it has a distinctive write head 39. Audio information is presented on the input of compression means 35, which may be placed in a separate housing. Suitable compression has been described in D2, D3 and D4. The variable bitrate compressed audio on the output of the compression means 35 is passed to buffer 36. From buffer 36 the data is passed to data combination means 37 for adding stuffing data and further control data. The total data stream is passed to writing means 38 for recording. Write head 39 is coupled to the writing means 38, which comprise for example a formatter, an error encoder and a channel encoder.

The data presented to the input of writing means⁶ 38 is distributed over logical and physical sectors according to formatting and encoding rules and converted into a write signal for the write head 39. Unit 20 is arranged for \controlling buffer 36, data combination means 37 and writing means 38 via control lines 26 and for performing the positioning procedure as described above for the reading apparatus. Alternatively the recording apparatus may be arranged for reading having the features of the playback apparatus and a combined write/read head.

Figure 4 shows a file system for use with the invention, for which various different options are feasible. As main choices the inventors have proposed that the storage medium should be based on either the UDF file system or the ISO 9660 file system, or both, which systems are standard to the skilled art person. In the alternative case, **no** file system would be present at all and the relevant sector spaces should be kept empty.

If a file system is present however, all audio will be stored in Audio Files, that are located in SubDirectory **SCD_AUDIO**. As shown in Figure 4, the hierarchy is based on **ROOT** file 50 that points to various subaltern files 52, 54, 56, 66 as shown. The structure of **MASTER.TOC** 52 will be discussed hereinafter. Furthermore, there is a **2C_AUDIO** file 54. This points to **TOC 2C_AREA.TOC** 58 and in parallel therewith to the various stereo tracks **TRACKn.2CH** 60. Furthermore, there is **MC_AUDIO** file 56. This points to **TOC MC_AREA.TOC** 62 and in parallel therewith to the various stereo tracks **TRACKn.MCH** 64. For reasons of safety, the **MASTER.TOC** has been provided in three contiguously positioned copies **MASTER1..3.TOC** 52. Likewise for reasons of safety, the subaltern TOCs have been provided in two copies **2C_AREA1,2.TOC** 58 and **MC_AREA1,2.TOC** 62, respectively. These two copies are positioned before and behind, respectively, the associated audio. As a further feature, the audio formats have an additional overall file each, **2C_TAREA.2CH** 59 and **MC_TAREA.MCH** that contain the file information of all associated track files, respectively. Finally, a picture file 66 has been provided that may be related to a similar organization as has been provided for the audio.

Figure 5 shows a first storage arrangement for use with the invention, which by way of example has been mapped on a single serial track. Along the horizontal axis the following items are evident. Item 120 is a **Lead-in** area that is used for mutually synchronizing the reader and the driving of the medium.

Item 122 represents the **File System** that has been disclosed with reference to Figure 4. Item 124
 5 represents a **TOC** that may be configured according to standard procedures and pertains to subsequent items **Stereo Audio**

Item 126 and Multi-channel Audio Item 128, and if necessary also to **Extra Data** Item 130.

The length of item 124 need not be standardized, inasmuch as various different amounts of information may be present. Item 126 represents **Stereo Audio Information**, that may be

10 defined according to a conventional standard and by itself does not constitute part of the invention. Item 128 represents **Multi Channel Audio Information**, that may be defined according to a conventional standard and by itself does not constitute part of the invention. Generally, the two audio areas may have the same structure and contain the same kinds of information, apart from the distinguishing definitions of the various channels. The audio may be
 15 plain coded or lossless coded. All kinds of audio may be multiplexed with supplementary data such as Compact Disc Text.

Item 130 represents **Extra Data Information** that may be defined in a conventional standard and by itself does not form part of the invention. Item 132 represents a **Lead-Out Information**. The latter item is used in particular during search operations. The
 20 number of lead-out tracks may be large enough to cover a ring of some 0.5 to 1 millimeter wide. According to the above, the stored information may either be accessed via the file system as laid down in item 122, or via the TOC structure laid down in item 124, and more particular, via a two- or multi-level TOC structure.

Figure 6 shows a second storage arrangement for use with the invention,
 25 pertaining to a two-level TOC structure. Along the horizontal axis the following items are evident, next to items that have already been shown in Figure 5 and carry the same reference numerals. For clarity, items 120 and 132 have been suppressed.

Master TOC 134 begins at a uniformly standardized offset position with respect to the start of the Lead-in area at byte number **510**. According to the embodiment, the
 30 Master-TOC measures only one standard-size sector and primarily contains pointers to the various Sub-TOCs or Area-TOCs. A preferred syntax of the Master-TOC has a header with a **Signature** that identifies the Master-TOC, such as by "SACD Master TOC ". Further, Tables 1 and 2 specify the precise syntax of the MASTER_TOC. The syntax has been given in elementary computer notation, together with the associated lengths and formats.

Master_TOC_Signature is an 8 byte string identifying the Master TOC. The value of

- 5 Master_TOC_Signature must be "SACDMTOC" (\$53 \$41 \$43 \$44 \$4D \$54 \$4F \$43).

Likewise Table 3 specifies the disc info syntax in the same manner. In particular:

- 2CH_TOC_1_Address is a 5 byte integer containing the logical sector number (LSN) of the
- 10 first sector of Area TOC-1 in the 2 Channel Stereo Area. If the 2-Channel Stereo Area is not present, the value of 2CH_TOC_1_Address must be zero.
- 2CH_TOC_2_Address is a 4 byte integer containing the LSN of the first sector of Area TOC-2 in the 2 Channel Stereo Area. If the 2-Channel Stereo Area is not present, the value of
- 15 2CH_TOC_2_Address must be zero.
- MC_TOC_1_Address is a 4 byte integer containing the LSN of the first sector of Area TOC-1 in the Multi Channel Stereo Area. If the Multi Channel Area is not present, the value of
- MC_TOC_1_Address must be zero.
- 20 MC_TOC_2_Address is a 4 byte integer containing the LSN of the first sector of Area TOC-2 in the Multi Channel Stereo Area. If the Multi Channel Area is not present, the value of
- MC_TOC_2_Address must be zero.

The format of Disc_Flags must be as follows: a hybrid bit and seven reserved bits.

- 25 The Hybr bit must be set to one on a Hybrid Disc. The Hybr bit must be set to zero on a not-Hybrid Disc.

List of related documents

- 30 (D1) Research Disclosure number 36411.
August 1994, page 412-413
- (D2) PCT/IB97/01156 (PHN 16.452)
1 bit ADC and lossless compression of audio

- (D3) PCT/IB97/01303 (PHN 16.405)
5 Audio compressor
- (D4) EP-A 402,973 (PHN 13.241)
Audio compression
- (D5) 'A digital decimating filter for analog-to-digital conversion of hi-fi audio signals',
10 by J.J. van der Kam in Philips Techn. Rev. 42, no. 6/7, April 1986, pp. 230-8
- (D6) 'A higher order topology for interpolative modulators for oversampling A/D
converters', by Kirk C.H. Chao et al in IEEE Trans. on Circuits and Systems, Vol 37, no. 3,
15 March 1990, pp. 309-18.

CLAIMS:

1. A method for storing audio-centered information on a unitary storage medium while using a Table-of-Contents (TOC) mechanism for therein specifying an actual configuration of various audio items on said medium,
being characterized by assigning one or more Sub-TOCs to each of a plurality of
5 differently standardized audio formats, and furthermore providing a single Master-TOC for specifically pointing to each of said Sub-TOCs.
2. A method as claimed in Claim 1, wherein the number of sub-TOCs is exactly
2.
- 10 3. A method as claimed in Claim 1, and furthermore providing said Master-TOC at a standard offset location with respect to an initial location of said medium.
4. A method as claimed in Claim 1, wherein said audio formats comprise at
15 least a Stereo format and at least one Multi-Channel audio format.
5. A method as claimed in Claim 1, and furthermore providing at least one Extra Data format area.
- 20 6. A method as claimed in Claim 1, and furthermore providing at least one of said TOC and sub-TOCs in at least two copies for reason of safety.
7. A unitary medium produced by practising a method as claimed in Claim 1.
- 25 8. A medium as claimed in Claim 7 and executed as an optically readable disc.
9. A reader device for interfacing to a medium as claimed in Claim 6.

10. A device as claimed in Claim 9, and being provided with disc hold means, optical
5 read means and disc drive means for driving a disc track along said optical read means.