

CARRIAGE AND SIGNALING OF DISPLAY ATTENUATION MAPS IN ISOBMFF MEDIA CONTAINERS**CROSS-REFERENCE TO RELATED APPLICATIONS**

- [0001] The present application claims benefit of European Patent Application No. EP23306768, entitled "CARRIAGE AND SIGNALING OF DISPLAY ATTENUATION MAPS IN ISOBMFF MEDIA CONTAINERS" and filed October 11, 2023, which is hereby incorporated by reference in its entirety.

BACKGROUND

- [0002] Reducing energy consumption of electronic devices has become desirable not only for electronic devices manufacturers but also to limit, as much as possible, the environmental impact and to contribute to the emergence of a sustainable display industry.
- 10 [0003] The increase in display resolution from SD to HD to 4K and soon to 8K and beyond, as well as the introduction of high dynamic range imaging, has brought about a corresponding increase in energy requirements of display devices. This is not consistent with the global need to reduce energy consumption. Displays are believed to be an important source of energy consumption, whether it be for battery-powered devices (e.g., smartphones) or in the global video distribution chain.
- 15 [0004] Organic Light Emitting Diode (OLED) displays are getting more and more popular because of numerous advantages compared to non-emissive displays such as Thin-Film Transistor Liquid Crystal Displays (TFT-LCDs). Rather than using a uniform backlight, OLED displays are composed of LEDs as image pixels. OLEDs power consumption is therefore highly correlated to the image content and can be readily estimated by considering the luminance level of the displayed image pixels.
- 20 [0005] Although OLED displays consume energy in a more controllable and efficient manner, they are still a significant source of energy consumption in a video transmission chain. It is therefore desirable to implement energy-aware images, which use less energy when displayed on displays, notably OLED displays. Examples of such implementations are described in European patent application nos. EP22306719.0 (22 Nov. 2022) and EP23305185.3 (10 Feb. 2023), both entitled "Lightweight Deep Network Based Method and
- 25 Device for Generating a Dimming Map". They describe techniques to build energy-aware images, based on the learning of a dimming map with good properties such as a smoothness property and a scalable property.

[0006] European patent application nos. EP22306908.9 (16 Dec. 2022), EP23305521.9 (7 April 2023), and EP23306066.4 (29 June 2023), all entitled, "Method and Device for Encoding and Decoding Attenuation Map for Energy Aware Images", describe signaling solutions to transmit the dimming maps and make them available for use at the display side of the chain. In these solutions, a new SEI message is created, and the dimming maps are transmitted as auxiliary data up to the receiver side. This message, conveyed within the
5 codec signaling, aims at guiding the use of the pixel-wise display attenuation map.

[0007] European patent application no. EP23306227.2 (17 July 2023), entitled "ISOBMFF Carriage of Attenuation Map Information for Energy-Aware Images in a Dash Context," describes a system for selection by a client and delivery by a server of energy-aware video.

10 SUMMARY

[0008] A first example method in accordance with some embodiments may include: obtaining a container file, wherein the container file includes: at least one video track representing an encoded video, and a first attenuation map track representing a first attenuation map data stream, the first attenuation map track including a first information box characterizing the first attenuation map data stream.

15 [0009] For some embodiments of the first example method, the first information box identifies first pre-processing operations to be applied to samples of the first attenuation map stream.

[0010] For some embodiments of the first example method, the first information box identifies a first energy reduction rate associated with the first attenuation map data stream.

20 [0011] For some embodiments of the first example method, the first information box identifies a first quality reduction associated with the first attenuation map data stream.

[0012] For some embodiments of the first example method, the first information box identifies a first set of color components to which the first attenuation map data stream is to be applied.

[0013] For some embodiments of the first example method, the first attenuation map track is a timed-metadata track.

25 [0014] For some embodiments of the first example method, the first attenuation map track includes a plurality of samples, and each sample carries coded video units for an attenuation map corresponding to a coded video frame in the video track.

[0015] For some embodiments of the first example method, the first attenuation map track is a restricted video track.

[0016] For some embodiments of the first example method, the first information box is stored in a first restricted scheme information box.

[0017] For some embodiments of the first example method, the first attenuation map track is an auxiliary video track.

- 5 [0018] For some embodiments of the first example method, the first attenuation map track includes a track reference type box, and wherein the track reference type box includes a track identifier identifying at least one of the video tracks.

[0019] For some embodiments of the first example method, at least one of the video tracks includes a track reference type box, and wherein the track reference type box includes a track identifier identifying the first attenuation map track.
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[0020] For some embodiments of the first example method, the container file includes a plurality of attenuation map tracks including the first attenuation map track, each of the attenuation map tracks including a track header box, and wherein a plurality of the attenuation map tracks have identical values of an alternative group field in their respective track header boxes.

- 15 [0021] For some embodiments of the first example method, the container file includes a plurality of attenuation map tracks including the first attenuation map track, and wherein each of the attenuation map tracks includes a track group box associating the plurality of attenuation map tracks into a track group.

[0022] Some embodiments of the first example method may further include, at a decoder: decoding the video track to obtain a decoded video; decoding the first attenuation map track to obtain a decoded
20 attenuation map; and applying the decoded attenuation map to the decoded video to obtain an attenuated video.

[0023] For some embodiments of the first example method, the decoded attenuation map is applied to the decoded video according to information in the first information box.

[0024] Some embodiments of the first example method may further include displaying the attenuated
25 video.

[0025] Some embodiments of the first example method may further include, at a server: based on information received from a client, selecting the first attenuation map track from among a plurality of attenuation map tracks in the container file; and streaming the video track and the first attenuation map track to the client.

[0026] For some embodiments of the first example method, the first attenuation map track is selected based on information in the first information box.

[0027] For some embodiments of the first example method, the first attenuation map track is selected based on the first energy reduction rate associated with the first attenuation map data stream.

5 [0028] For some embodiments of the first example method, the first attenuation map track is selected based on the first quality reduction associated with the first attenuation map data stream.

[0029] For some embodiments of the first example method, the container file is an ISOBMFF file.

[0030] A first example apparatus in accordance with some embodiments may include: a processor; and a non-transitory computer-readable medium storing instructions operative, when executed by the processor,
10 to cause the apparatus to perform any one of the methods listed above.

[0031] A second example apparatus in accordance with some embodiments may include at least one processor configured to perform any one of the methods listed above.

[0032] A third example apparatus in accordance with some embodiments may include a computer-readable medium storing instructions for causing one or more processors to perform any one of the methods
15 listed above.

[0033] A fourth example apparatus in accordance with some embodiments may include: at least one processor and at least one non-transitory computer-readable medium storing instructions for causing the at least one processor to perform any one of the methods listed above.

[0034] A first example computer-readable medium storing a container file in accordance with some
20 embodiments, wherein the container file may include: at least one video track representing an encoded video, and a first attenuation map track representing a first attenuation map data stream, the first attenuation map track including a first information box characterizing the first attenuation map data stream.

[0035] A second example computer-readable medium storing a container file in accordance with some
25 embodiments, wherein the container file may include: at least one video track representing an encoded video, and a first attenuation map track representing a first attenuation map data stream, the first attenuation map track including a first information box characterizing the first attenuation map data stream.

[0036] For some embodiments of the second example computer-readable medium, the first information box identifies first pre-processing operations to be applied to samples of the first attenuation map stream.

[0037] For some embodiments of the second example computer-readable medium, the first information
30 box identifies a first energy reduction rate associated with the first attenuation map data stream.

- [0038] For some embodiments of the second example computer-readable medium, the first information box identifies a first quality reduction associated with the first attenuation map data stream.
- [0039] For some embodiments of the second example computer-readable medium, the first information box identifies a first set of color components to which the first attenuation map data stream is to be applied.
- 5 [0040] For some embodiments of the second example computer-readable medium, the first attenuation map track is a timed-metadata track.
- [0041] For some embodiments of the second example computer-readable medium, the first attenuation map track includes a plurality of samples, and wherein each sample carries coded video units for an attenuation map corresponding to a coded video frame in the video track.
- 10 [0042] For some embodiments of the second example computer-readable medium, the first attenuation map track is a restricted video track.
- [0043] For some embodiments of the second example computer-readable medium, the first information box is stored in a first restricted scheme information box.
- [0044] For some embodiments of the second example computer-readable medium, the first attenuation
15 map track is an auxiliary video track.
- [0045] For some embodiments of the second example computer-readable medium, the first attenuation map track includes a track reference type box, and wherein the track reference type box includes a track identifier identifying at least one of the video tracks.
- [0046] For some embodiments of the second example computer-readable medium, at least one of the
20 video tracks includes a track reference type box, and wherein the track reference type box includes a track identifier identifying the first attenuation map track.
- [0047] For some embodiments of the second example computer-readable medium, the container file includes a plurality of attenuation map tracks including the first attenuation map track, each of the attenuation map tracks including a track header box, and wherein a plurality of the attenuation map tracks have identical
25 values of an alternative group field in their respective track header boxes.
- [0048] For some embodiments of the second example computer-readable medium, the container file includes a plurality of attenuation map tracks including the first attenuation map track, and wherein each of the attenuation map tracks includes a track group box associating the plurality of attenuation map tracks into a track group.

[0049] For some embodiments of the second example computer-readable medium, the container file is an ISOBMFF file.

BRIEF DESCRIPTION OF THE DRAWINGS

5 [0050] The following detailed description will be better understood when read in conjunction with the appended drawings, in which there are shown examples of one or more of the multiple embodiments of the present disclosure. It should be understood, however, that the embodiments described herein are not limited to the precise arrangements and instrumentalities shown in the drawings. In the drawings:

[0051] FIG. 1A is a system diagram illustrating an example communications system according to some embodiments.

10 [0052] FIG. 1B is a system diagram illustrating an example wireless transmit/receive unit (WTRU) that may be used within the communications system illustrated in FIG. 1A according to some embodiments.

[0053] FIG. 1C is a system diagram illustrating an example set of interfaces for a system according to some embodiments.

15 [0054] FIG. 2 is a schematic illustration showing an example DASH system architecture according to some embodiments.

[0055] FIG. 3 is a schematic illustration showing an example hierarchy for an MPD XML manifest file according to some embodiments.

[0056] FIG. 4 is a schematic illustration showing an example video and attenuation map representation preparation at the Dash server side according to some embodiments.

20 [0057] FIG. 5 is a schematic illustration showing example DASH client interfaces according to some embodiments.

[0058] FIG. 6A is a flowchart illustrating an example DASH server-side application process according to some embodiments.

25 [0059] FIG. 6B is a flowchart illustrating an example DASH server-side application process according to some embodiments.

[0060] FIG. 7 is a flowchart illustrating an example DASH client-side process according to some embodiments.

[0061] FIG. 8 is a schematic illustration showing an example DASH client-side process according to some embodiments.

[0062] FIG. 9 is a flowchart illustrating an example process for handling an attenuation map according to some embodiments.

[0063] FIG. 10 is a flowchart illustrating an example process for handling an attenuation map according to some embodiments.

- 5 [0064] The entities, connections, arrangements, and the like that are depicted in—and described in connection with—the various figures are presented by way of example and not by way of limitation. As such, any and all statements or other indications as to what a particular figure “depicts,” what a particular element or entity in a particular figure “is” or “has,” and any and all similar statements—that may in isolation and out of context be read as absolute and therefore limiting—may only properly be read as being constructively
10 preceded by a clause such as “In at least one embodiment,” For brevity and clarity of presentation, this implied leading clause is not repeated *ad nauseum* in the detailed description.

DETAILED DESCRIPTION

- [0065] In describing the various embodiments of the present disclosure, certain terminology is used herein for convenience only and should not be considered as limiting such embodiments. In the drawings, the same
15 reference numerals are employed for designating the same elements throughout the several figures and the present description.

[0066] The embodiments described herein are not limited to any particular type or structure of XR display device.

- [0067] A User Equipment (UE) may correspond to any eXtended Reality (XR) device/node which may
20 come in variety of form factors. Typical UE (e.g., XR UE) may include, but not limited to the following: Head Mounted Displays (HMD), optical see-through glasses and video see-through HMDs for Augmented Reality (AR) and Mixed Reality (MR), mobile devices with positional tracking and camera, wearables etc. In addition to the above, several different types of XR UE may be envisioned based on XR device functions for e.g., as display, camera, sensors, sensor processing, wireless connectivity, XR/Media processing, and power supply,
25 to be provided by one or more devices, wearables, actuators, controllers and/or accessories. One or more device/nodes/UEs may be grouped into a collaborative XR group for supporting any of XR applications/experience/services.

Overview of Metadata for Energy Savings

- [0068] The present disclosure proposes an alternative to the use of SEI messages by defining the carriage
30 of coded media representations which comply with display attenuation map video-based coding and relative

attenuation map information (AMI) within an ISO base media file format (ISOBMFF) media container, as specified in the ISO/IEC 14496-12 specification.

[0069] The ISO/IEC 23001-11 specification specifies metadata, referred to as *green metadata*, that facilitate the reduction of energy usage during media consumption (i.e., decoding and display operations),
5 and specifically for reducing the display power consumption.

[0070] The metadata for display adaptation are defined in clause 7 (display power reduction using display adaptation) of ISO/IEC 23001-11. These metadata are particularly well tailored to display technologies based on non-emissive pixels and embedding backlight illumination such as LCD. They are designed to attain display energy reductions by using display adaptation techniques that generate dynamically, on the emitter
10 side, some RGB-component statistics and quality indicators metrics about the consumed video content. They can be used to perform RGB picture components rescaling to set the best compromise between backlight/voltage reduction and picture quality, reducing voltage, and therefore allowing to reduce the energy consumption. However, it is far from being optimal, as these metadata convey global information and do not convey any information that would help the use of a pixel-wise attenuation map, as such a map is not useful
15 for non-emissive pixel types of displays.

[0071] In terms of solutions to convey the attenuation map information, a user data SEI message registered by ITU-T Recommendation T.35 also exists, but their genericity makes them inefficient for the current use case.

[0072] A *display attenuation map* video is a 2D video created by a video content analyzer through pixel-wise energy-aware frame algorithm which has properties such as smoothness and scalability properties. One
20 such algorithm is described in Le Meur et al., "*Energy-aware images: Quality of Experience vs Energy Reduction*", Proceedings of the 2nd Mile-High Video (MHV) Conference, May 2023.

[0073] An operation is performed on the analyzed video based on the information conveyed in the display attenuation map. This operation strategically implements reductions in the brightness of the frames to
25 optimize the tradeoff between quality of experience (QoE) and energy reduction.

[0074] The related attenuation map information contains the characteristics of the attenuation map, such as the display target model, width, length, and energy reduction rate, and information indicating the operation to be used to apply it to the original video before rendering the video on the display.

[0075] Within the ISO/IEC 14496 (MPEG-4) standard there are several parts that define file formats for the storage of time-based media. These are all based on and derived from the ISO Base Media File Format
30 (ISOBMFF), which is a structural, media-independent definition. ISOBMFF contains structural and media

data information mainly for timed presentations of media data such as audio, video, etc. There is also support for un-timed data, such as meta-data at different levels within the file structure. The logical structure of the file is of a *movie* that in turn contains a set of time-parallel *tracks*. The time structure of the file is that the *tracks* contain sequences of *samples* in time, and those sequences are mapped into the timeline of the overall movie. ISO BMFF is based on the concept of box-structured files. A box-structured file consists of a series of boxes (sometimes called atoms), which have a size and a type. The types are 32-bit values and usually chosen to be four printable characters, also known as a four-character code (4CC). Un-timed data may be contained in a metadata box, at the file level, or attached to the movie box or one of the streams of timed data, called *tracks*, within the movie.

10 [0076] Among the top-level boxes within an ISO BMFF container is the `MovieBox` ('moov') which contains metadata for the continuous media streams present in the file. These metadata are signaled within the hierarchy of boxes in the Movie box, e.g., within the `TrackBox` ('trak').

[0077] A track represents a continuous media stream that is present in the file. The media stream itself consists of a sequence of samples, such as audio or video access units of an elementary media stream, and are enclosed within a `MediaDataBox` ('mdat') that is present at the top-level of the container. The metadata for each track includes a list of sample description entries, each providing the coding or encapsulation format used in the track and the initialization data for processing that format. Each sample is associated with one of the sample description entries of the track.

Overview of Example Communications Systems

20 [0078] FIG. 1A is a diagram illustrating an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems 25 100 may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), zero-tail unique-word DFT-Spread OFDM (ZT UW DTS-s OFDM), unique word OFDM (UW-OFDM), resource block-filtered OFDM, filter bank multicarrier (FBMC), and the like.

[0079] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, 102d, a RAN 104, a CN 106, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments

contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d, any of which may be referred to as a “station” and/or a “STA”, may be configured to transmit and/or receive wireless signals and may include a
5 user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a subscription-based unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, a hotspot or Mi-Fi device, an Internet of Things (IoT) device, a watch or other wearable, a head-mounted display (HMD), a vehicle, a drone, a medical device and applications (e.g., remote surgery), an industrial device and applications (e.g., a robot and/or other wireless devices operating in an
10 industrial and/or an automated processing chain contexts), a consumer electronics device, a device operating on commercial and/or industrial wireless networks, and the like. Any of the WTRUs 102a, 102b, 102c and 102d may be interchangeably referred to as a UE.

[0080] The communications systems 100 may also include a base station 114a and/or a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with
15 at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to one or more communication networks, such as the CN 106, the Internet 110, and/or the other networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a gNB, a NR NodeB, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the
20 base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0081] The base station 114a may be part of the RAN 104, which may also include other base stations and/or network elements (not shown), such as a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals on one or more carrier frequencies, which may be referred to as a cell (not
25 shown). These frequencies may be in licensed spectrum, unlicensed spectrum, or a combination of licensed and unlicensed spectrum. A cell may provide coverage for a wireless service to a specific geographical area that may be relatively fixed or that may change over time. The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, i.e., one for each sector of the cell. In an
30 embodiment, the base station 114a may employ multiple-input multiple output (MIMO) technology and may utilize multiple transceivers for each sector of the cell. For example, beamforming may be used to transmit and/or receive signals in desired spatial directions.

[0082] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 116, which may be any suitable wireless communication link (e.g., radio frequency (RF), microwave, centimeter wave, micrometer wave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface 116 may be established using any suitable radio access technology (RAT).

- 5 [0083] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 104 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 116 using wideband CDMA
10 (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink (DL) Packet Access (HSDPA) and/or High-Speed UL Packet Access (HSUPA).

- [0084] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air
15 interface 116 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A) and/or LTE-Advanced Pro (LTE-A Pro).

[0085] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as NR Radio Access, which may establish the air interface 116 using New Radio (NR).

- 20 [0086] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement multiple radio access technologies. For example, the base station 114a and the WTRUs 102a, 102b, 102c may implement LTE radio access and NR radio access together, for instance using dual connectivity (DC) principles. Thus, the air interface utilized by WTRUs 102a, 102b, 102c may be characterized by multiple types of radio access technologies and/or transmissions sent to/from multiple types of base stations (e.g., a
25 eNB and a gNB).

- [0087] In other embodiments, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.11 (i.e., Wireless Fidelity (WiFi)), IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for
30 Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), and the like.

[0088] The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, an industrial facility, an air corridor (e.g., for use by drones), a roadway, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In an embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet another embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (e.g., WCDMA, CDMA2000, GSM, LTE, LTE-A, LTE-A Pro, NR etc.) to establish a picocell or femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the CN 106.

[0089] The RAN 104 may be in communication with the CN 106, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. The data may have varying quality of service (QoS) requirements, such as differing throughput requirements, latency requirements, error tolerance requirements, reliability requirements, data throughput requirements, mobility requirements, and the like. The CN 106 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, such as user authentication. Although not shown in FIG. 1A, it will be appreciated that the RAN 104 and/or the CN 106 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 104 or a different RAT. For example, in addition to being connected to the RAN 104, which may be utilizing a NR radio technology, the CN 106 may also be in communication with another RAN (not shown) employing a GSM, UMTS, CDMA 2000, WiMAX, E-UTRA, or WiFi radio technology.

[0090] The CN 106 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or the other networks 112. The PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and/or the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired and/or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another CN connected to one or more RANs, which may employ the same RAT as the RAN 104 or a different RAT.

[0091] Some or all of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities (e.g., the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links). For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0092] FIG. 1B is a system diagram illustrating an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 130, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and/or other peripherals 138, among others. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment.

[0093] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0094] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (e.g., the base station 114a) over the air interface 116. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In an embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet another embodiment, the transmit/receive element 122 may be configured to transmit and/or receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0095] Although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ

MIMO technology. Thus, in one embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (e.g., multiple antennas) for transmitting and receiving wireless signals over the air interface 116.

5 [0096] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, such as NR and IEEE 802.11, for example.

10 [0097] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (e.g., a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, such as the non-removable memory 130 and/or the removable memory 132. The non-removable memory 130 may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In other embodiments, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, such as on a server or a home computer (not shown).

20 [0098] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (e.g., nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

25 [0099] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (e.g., longitude and latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 116 from a base station (e.g., base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

30

[0100] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs and/or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, a Virtual Reality and/or Augmented Reality (VR/AR) device, an activity tracker, and the like. The peripherals 138 may include one or more sensors, the sensors may be one or more of a gyroscope, an accelerometer, a hall effect sensor, a magnetometer, an orientation sensor, a proximity sensor, a temperature sensor, a time sensor; a geolocation sensor; an altimeter, a light sensor, a touch sensor, a magnetometer, a barometer, a gesture sensor, a biometric sensor, and/or a humidity sensor.

[0101] The WTRU 102 may include a full duplex radio for which transmission and reception of some or all of the signals (e.g., associated with particular subframes for both the UL (e.g., for transmission) and downlink (e.g., for reception) may be concurrent and/or simultaneous. The full duplex radio may include an interference management unit to reduce and or substantially eliminate self-interference via either hardware (e.g., a choke) or signal processing via a processor (e.g., a separate processor (not shown) or via processor 118). In an embodiment, the WTRU 102 may include a half-duplex radio for which transmission and reception of some or all of the signals (e.g., associated with particular subframes for either the UL (e.g., for transmission) or the downlink (e.g., for reception)).

[0102] Although the WTRU is described in FIGs. 1A-1B as a wireless terminal, it is contemplated that in certain representative embodiments that such a terminal may use (e.g., temporarily or permanently) wired communication interfaces with the communication network.

[0103] In representative embodiments, the other network 112 may be a WLAN.

[0104] In view of FIGs. 1A-1B, and the corresponding description, one or more, or all, of the functions described herein may be performed by one or more emulation devices (not shown). The emulation devices may be one or more devices configured to emulate one or more, or all, of the functions described herein. For example, the emulation devices may be used to test other devices and/or to simulate network and/or WTRU functions.

[0105] The emulation devices may be designed to implement one or more tests of other devices in a lab environment and/or in an operator network environment. For example, the one or more emulation devices may perform the one or more, or all, functions while being fully or partially implemented and/or deployed as part of a wired and/or wireless communication network in order to test other devices within the communication

network. The one or more emulation devices may perform the one or more, or all, functions while being temporarily implemented/deployed as part of a wired and/or wireless communication network. The emulation device may be directly coupled to another device for purposes of testing and/or may performing testing using over-the-air wireless communications.

- 5 **[0106]** The one or more emulation devices may perform the one or more, including all, functions while not being implemented/deployed as part of a wired and/or wireless communication network. For example, the emulation devices may be utilized in a testing scenario in a testing laboratory and/or a non-deployed (e.g., testing) wired and/or wireless communication network in order to implement testing of one or more components. The one or more emulation devices may be test equipment. Direct RF coupling and/or wireless
10 communications via RF circuitry (e.g., which may include one or more antennas) may be used by the emulation devices to transmit and/or receive data.

- [0107]** The embodiments described herein are not limited to being implemented on a WTRU. Such embodiments may be implemented using other systems, such as the system of FIG. 1C. FIG. 1C is a system diagram illustrating an example set of interfaces for a system according to some embodiments. An extended
15 reality display device, together with its control electronics, may be implemented using a system such as the system of FIG. 1C. System 150 can be embodied as a device including the various components described below and is configured to perform one or more of the aspects described in this document. Examples of such devices, include, but are not limited to, various electronic devices such as personal computers, laptop computers, smartphones, tablet computers, digital multimedia set top boxes, digital television receivers,
20 personal video recording systems, connected home appliances, and servers. Elements of system 150, singly or in combination, can be embodied in a single integrated circuit (IC), multiple ICs, and/or discrete components. For example, in at least one embodiment, the processing and encoder/decoder elements of system 150 are distributed across multiple ICs and/or discrete components. In various embodiments, the system 150 is communicatively coupled to one or more other systems, or other electronic devices, via, for
25 example, a communications bus or through dedicated input and/or output ports. In various embodiments, the system 1000 is configured to implement one or more of the aspects described in this document.

- [0108]** The system 150 includes at least one processor 152 configured to execute instructions loaded therein for implementing, for example, the various aspects described in this document. Processor 152 may include embedded memory, input output interface, and various other circuitries as known in the art. The
30 system 150 includes at least one memory 154 (e.g., a volatile memory device, and/or a non-volatile memory device). System 150 may include a storage device 158, which can include non-volatile memory and/or volatile memory, including, but not limited to, Electrically Erasable Programmable Read-Only Memory (EEPROM),

Read-Only Memory (ROM), Programmable Read-Only Memory (PROM), Random Access Memory (RAM), Dynamic Random Access Memory (DRAM), Static Random Access Memory (SRAM), flash, magnetic disk drive, and/or optical disk drive. The storage device 158 can include an internal storage device, an attached storage device (including detachable and non-detachable storage devices), and/or a network accessible storage device, as non-limiting examples.

[0109] System 150 includes an encoder/decoder module 156 configured, for example, to process data to provide an encoded video or decoded video, and the encoder/decoder module 156 can include its own processor and memory. The encoder/decoder module 156 represents module(s) that can be included in a device to perform the encoding and/or decoding functions. As is known, a device can include one or both of the encoding and decoding modules. Additionally, encoder/decoder module 156 can be implemented as a separate element of system 150 or can be incorporated within processor 152 as a combination of hardware and software as known to those skilled in the art.

[0110] Program code to be loaded onto processor 152 or encoder/decoder 156 to perform the various aspects described in this document can be stored in storage device 158 and subsequently loaded onto memory 154 for execution by processor 152. In accordance with various embodiments, one or more of processor 152, memory 154, storage device 158, and encoder/decoder module 156 can store one or more of various items during the performance of the processes described in this document. Such stored items can include, but are not limited to, the input video, the decoded video or portions of the decoded video, the bitstream, matrices, variables, and intermediate or final results from the processing of equations, formulas, operations, and operational logic.

[0111] In some embodiments, memory inside of the processor 152 and/or the encoder/decoder module 156 is used to store instructions and to provide working memory for processing that is needed during encoding or decoding. In other embodiments, however, a memory external to the processing device (for example, the processing device can be either the processor 152 or the encoder/decoder module 152) is used for one or more of these functions. The external memory can be the memory 154 and/or the storage device 158, for example, a dynamic volatile memory and/or a non-volatile flash memory. In several embodiments, an external non-volatile flash memory is used to store the operating system of, for example, a television. In at least one embodiment, a fast external dynamic volatile memory such as a RAM is used as working memory for video coding and decoding operations, such as for MPEG-2 (MPEG refers to the Moving Picture Experts Group, MPEG-2 is also referred to as ISO/IEC 13818, and 13818-1 is also known as H.222, and 13818-2 is also known as H.262), HEVC (HEVC refers to High Efficiency Video Coding, also known as H.265 and

MPEG-H Part 2), or VVC (Versatile Video Coding, a new standard being developed by JVET, the Joint Video Experts Team).

[0112] The input to the elements of system 150 can be provided through various input devices as indicated in block 172. Such input devices include, but are not limited to, (i) a radio frequency (RF) portion that receives
5 an RF signal transmitted, for example, over the air by a broadcaster, (ii) a Component (COMP) input terminal (or a set of COMP input terminals), (iii) a Universal Serial Bus (USB) input terminal, and/or (iv) a High Definition Multimedia Interface (HDMI) input terminal. Other examples, not shown in FIG. 1C, include composite video.

[0113] In various embodiments, the input devices of block 172 have associated respective input
10 processing elements as known in the art. For example, the RF portion can be associated with elements suitable for (i) selecting a desired frequency (also referred to as selecting a signal, or band-limiting a signal to a band of frequencies), (ii) downconverting the selected signal, (iii) band-limiting again to a narrower band of frequencies to select (for example) a signal frequency band which can be referred to as a channel in
15 certain embodiments, (iv) demodulating the downconverted and band-limited signal, (v) performing error correction, and (vi) demultiplexing to select the desired stream of data packets. The RF portion of various embodiments includes one or more elements to perform these functions, for example, frequency selectors, signal selectors, band-limiters, channel selectors, filters, downconverters, demodulators, error correctors, and demultiplexers. The RF portion can include a tuner that performs various of these functions, including,
20 for example, downconverting the received signal to a lower frequency (for example, an intermediate frequency or a near-baseband frequency) or to baseband. In one set-top box embodiment, the RF portion and its associated input processing element receives an RF signal transmitted over a wired (for example, cable) medium, and performs frequency selection by filtering, downconverting, and filtering again to a desired frequency band. Various embodiments rearrange the order of the above-described (and other) elements, remove some of these elements, and/or add other elements performing similar or different functions. Adding
25 elements can include inserting elements in between existing elements, such as, for example, inserting amplifiers and an analog-to-digital converter. In various embodiments, the RF portion includes an antenna.

[0114] Additionally, the USB and/or HDMI terminals can include respective interface processors for connecting system 150 to other electronic devices across USB and/or HDMI connections. It is to be understood that various aspects of input processing, for example, Reed-Solomon error correction, can be
30 implemented, for example, within a separate input processing IC or within processor 152 as necessary. Similarly, aspects of USB or HDMI interface processing can be implemented within separate interface ICs or within processor 152 as necessary. The demodulated, error corrected, and demultiplexed stream is provided

to various processing elements, including, for example, processor 152, and encoder/decoder 156 operating in combination with the memory and storage elements to process the datastream as necessary for presentation on an output device.

5 [0115] Various elements of system 150 can be provided within an integrated housing, Within the integrated housing, the various elements can be interconnected and transmit data therebetween using suitable connection arrangement 174, for example, an internal bus as known in the art, including the Inter-IC (I2C) bus, wiring, and printed circuit boards.

10 [0116] The system 150 includes communication interface 160 that enables communication with other devices via communication channel 162. The communication interface 160 can include, but is not limited to, a transceiver configured to transmit and to receive data over communication channel 162. The communication interface 160 can include, but is not limited to, a modem or network card and the communication channel 162 can be implemented, for example, within a wired and/or a wireless medium.

15 [0117] Data is streamed, or otherwise provided, to the system 150, in various embodiments, using a wireless network such as a Wi-Fi network, for example IEEE 802.11 (IEEE refers to the Institute of Electrical and Electronics Engineers). The Wi-Fi signal of these embodiments is received over the communications channel 162 and the communications interface 160 which are adapted for Wi-Fi communications. The communications channel 162 of these embodiments is typically connected to an access point or router that provides access to external networks including the Internet for allowing streaming applications and other over-the-top communications. Other embodiments provide streamed data to the system 150 using a set-top box that delivers the data over the HDMI connection of the input block 172. Still other embodiments provide streamed data to the system 150 using the RF connection of the input block 172. As indicated above, various
20 embodiments provide data in a non-streaming manner. Additionally, various embodiments use wireless networks other than Wi-Fi, for example a cellular network or a Bluetooth network.

25 [0118] The system 150 can provide an output signal to various output devices, including a display 176, speakers 178, and other peripheral devices 180. The display 176 of various embodiments includes one or more of, for example, a touchscreen display, an organic light-emitting diode (OLED) display, a curved display, and/or a foldable display. The display 176 can be for a television, a tablet, a laptop, a cell phone (mobile phone), or other device. The display 176 can also be integrated with other components (for example, as in a smart phone), or separate (for example, an external monitor for a laptop). The other peripheral devices 180
30 include, in various examples of embodiments, one or more of a stand-alone digital video disc (or digital versatile disc) (DVR, for both terms), a disk player, a stereo system, and/or a lighting system. Various

embodiments use one or more peripheral devices 180 that provide a function based on the output of the system 150. For example, a disk player performs the function of playing the output of the system 150.

[0119] In various embodiments, control signals are communicated between the system 150 and the display 176, speakers 178, or other peripheral devices 180 using signaling such as AV.Link, Consumer
5 Electronics Control (CEC), or other communications protocols that enable device-to-device control with or without user intervention. The output devices can be communicatively coupled to system 1000 via dedicated connections through respective interfaces 164, 166, and 168. Alternatively, the output devices can be connected to system 150 using the communications channel 162 via the communications interface 160. The display 176 and speakers 178 can be integrated in a single unit with the other components of system 150 in
10 an electronic device such as, for example, a television. In various embodiments, the display interface 164 includes a display driver, such as, for example, a timing controller (T Con) chip.

[0120] The display 176 and speaker 178 can alternatively be separate from one or more of the other components, for example, if the RF portion of input 172 is part of a separate set-top box. In various embodiments in which the display 176 and speakers 178 are external components, the output signal can be
15 provided via dedicated output connections, including, for example, HDMI ports, USB ports, or COMP outputs.

[0121] The system 150 may include one or more sensor devices 168. Examples of sensor devices that may be used include one or more GPS sensors, gyroscopic sensors, accelerometers, light sensors, cameras, depth cameras, microphones, and/or magnetometers. Such sensors may be used to determine information such as user's position and orientation. Where the system 150 is used as the control module for an extended
20 reality display (such as control modules 124, 132), the user's position and orientation may be used in determining how to render image data such that the user perceives the correct portion of a virtual object or virtual scene from the correct point of view. In the case of head-mounted display devices, the position and orientation of the device itself may be used to determine the position and orientation of the user for the purpose of rendering virtual content. In the case of other display devices, such as a phone, a tablet, a
25 computer monitor, or a television, other inputs may be used to determine the position and orientation of the user for the purpose of rendering content. For example, a user may select and/or adjust a desired viewpoint and/or viewing direction with the use of a touch screen, keypad or keyboard, trackball, joystick, or other input. Where the display device has sensors such as accelerometers and/or gyroscopes, the viewpoint and orientation used for the purpose of rendering content may be selected and/or adjusted based on motion of
30 the display device.

[0122] The embodiments can be carried out by computer software implemented by the processor 152 or by hardware, or by a combination of hardware and software. As a non-limiting example, the embodiments

can be implemented by one or more integrated circuits. The memory 154 can be of any type appropriate to the technical environment and can be implemented using any appropriate data storage technology, such as optical memory devices, magnetic memory devices, semiconductor-based memory devices, fixed memory, and removable memory, as non-limiting examples. The processor 152 can be of any type appropriate to the technical environment, and can encompass one or more of microprocessors, general purpose computers, special purpose computers, and processors based on a multi-core architecture, as non-limiting examples.

Example Container File Structure

[0123] Example embodiments disclosed herein address the issue of providing a mechanism for carrying video-coded display attenuation maps and related attenuation map information in media container files. In some embodiments, the media container files are based on the ISO base media file format defined in the ISO/IEC 14496-12 specification.

[0124] Display Attenuation Map video frames may be stored in ISO base media files as media samples of a media tracks using the various tools defined in ISO/IEC 14496-12. This track will be associated to the video media track and will not be presented on the display but will be used for post-processing purposes.

[0125] This will add the capability for the service provider to use this solution instead of using SEI messages and auxiliary data within the codec bitstream.

[0126] Embodiments described in the present disclosure provide a solution that enables flexible carriage of display attenuation maps and relative attenuation map information to associate these attenuation maps with video data in ISOBMFF media containers. Example embodiments support flexible and efficient selection of attenuation maps that optimize the display energy consumption of playback devices in streaming services.

[0127] In an example embodiment, video-coded display attenuation maps are carried as separate tracks in an ISOBMFF media container. The attenuation maps carried by these tracks are not presented on the display but can be applied to video frames in associated video tracks. To link the display attenuation map track with the video tracks carrying the relevant video, the track referencing tool in ISO/IEC 14496-12 may be used. In addition to the per frame attenuation maps, a display attenuation map track may also include information pertaining to the characteristics of the carried attenuation map data, including information identifying pre-processing operations that are to be applied to the samples of the attenuation map stream.

[0128] In some embodiments, an `AttenuationMapInformationBox` may be identified in the ISOBMFF file by the 4CC assigned to its `box_type` field. This box contains information about the characteristics of the display attenuation map data stream carried by the track in which it is signaled. This information may also include information identifying pre-processing operations that are to be applied to the

samples of the attenuation map stream. This information may further include information that may distinguish a track carrying an attenuation map stream from another track carrying another attenuation map stream for the same content, which enables a player to select the most suitable track based on certain conditions. In some embodiments, an AttenuationMapInformationBox may have the following syntax.

```

5  aligned(8) class AttenuationMapInformationBox() extends
    FullBox('amid') {
        bit(3) reserved = 0;
        unsigned int(1) ami_preprocessing_info_present_flag;
        unsigned int(1) ami_approx_model_present_flag;
10    unsigned int(1) ami_window_info_present_flag;
        unsigned int(1) ami_video_quality_info_present_flag;
        unsigned int(5) ami_energy_reduction_rate;
        unsigned int(4) ami_display_model;
        unsigned int(4) ami_attenuation_use_idc;
15    unsigned int(4) ami_attenuation_component_idc;

        if (ami_preprocessing_info_present) {
            AMIPreprocessingInfo();
        }
20    if (ami_approx_model_present_flag) {
        AMIAproximationModel();
        }
        if (ami_window_info_present_flag) {
            AMIWindowInfo();
25    }
        if (ami_video_quality_info_present_flag) {
            AMIVideoQualityInfo();
        }
    }
30  [0129] In some embodiments, the AttenuationMapInformationBox includes one or more of
the following data structures.
```

```

class AMIAproximationModel() {
    unsigned int(4) ami_map_approx_model;
```

```

}
aligned(8) class AMIWindowInfo() {
    unsigned int(8) ami_window_x;
    unsigned int(8) ami_window_y;
5    unsigned int(8) ami_window_width;
    unsigned int(8) ami_window_height;
}
class AMIVideoQualityInfo() {
    unsigned int(3) ami_quality_metric;
10    unsigned int(8) ami_quality_reduction;
}
class AMIPreprocessingInfo() {
    unsigned int(2) ami_preprocessing_type;
    unsigned int(8) ami_max_value;
15    unsigned int(8) ami_preprocessing_scale;
}

```

[0130] In some embodiments, the fields defined in AttenuationMapInformationBox have the following semantics.

20 **[0131]** `ami_processing_info_present_flag` is a flag indicating whether preprocessing information is present. Value 1 indicates that the box contains preprocessing information. The default value for this field is 0.

[0132] `ami_approx_model_present_flag` is a flag indicating whether approximation model information is present. Value 1 indicates that the box contains approximation model information.

25 **[0133]** `ami_window_info_present_flag` is a flag indicating whether window information is present. Value 1 indicates that the box contains window information.

[0134] `ami_video_quality_info_present_flag` is a flag indicating whether video quality information is present. Value 1 indicates that the box contains video quality information.

[0135] `ami_energy_reduction_rate` indicates the expected energy saving rate (percentage)
30 when the video is displayed after applying the attenuation map sample values on the sample values of the associated video.

[0136] `ami_display_model` indicates the display models on which the attenuation map sample values may be used. The semantics of the bits of this field are as described in Table 1.

Bit number	Display Model
0	Transmissive pixel
1	Emissive pixel
2 .. 3	Reserved for future use

Table 1. Semantics of the bits of the `ami_display_model` field

[0137] `ami_attenuation_use_idc` indicates which operation should be used to apply the attenuation map sample values to the corresponding frame in the associated video before rendering the frame on the display. The semantics of the values assigned to this field may be as follows:

- Value 0 indicates that the attenuation map sample values should be added to the video frame.
- Value 1 indicates that the attenuation map sample values should be subtracted from the video frame.
- Value 2 indicates that the attenuation map sample values should be multiplied by the video frame.
- Value 3 indicates that the attenuation map sample values should be applied to the video frame according to a proprietary used-defined process.

[0138] `ami_attenuation_component_idc` indicates on which color component(s) of the associated video to apply the attenuation map using the operation defined by `ami_attenuation_use_idc`. It also specifies how many components the attenuation map has. The semantics of the values assigned to this field may be as follows.

- Value 0 indicates that the attenuation map contains only one component, and that this component should be applied to the luma component of media video.
- Value 1 indicates that the attenuation map contains two components, and that the first component should be applied to the luma component of the media video, and the second component should be applied to both chroma components of the media video.
- Value 2 indicates that the attenuation map contains only one component, and that this component should be applied to the luma component and the chroma components of the media video.
- Value 3 indicates that the attenuation map contains only one component, and that this component should be applied to the RGB components (after YUV to RGB conversion) of the media video.
- Value 4 indicates that the attenuation map contains three components and that these components should be applied respectively to the luma and chroma components of the media video.

- Value 5 indicates that the attenuation map contains three components and that these components should be applied, respectively, to the RGB components (after YUV to RGB conversion) of the media video.
- Value 6 indicates that the mapping between the components of the attenuation map and the components of which to apply the attenuation map on the media video corresponds to a user-defined process.

[0139] `ami_preprocessing_type` indicates which type of pre-processing interpolation model should be used to re-sample the attenuation map sample values at the same resolution as the associated video before applying it to the associated video frame.

- Value 0 specifies an interpolation of type bicubic.
- Value 1 specifies an interpolation of type bilinear.
- Value 2 specifies an interpolation of type Lanczos.
- Value 3 specifies that a proprietary user-defined process is used.

[0140] `ami_max_value` indicates the maximum value of the attenuation map. This value can be optionally used to further adjust the dynamic range of the encoded attenuation map in the scaling process.

[0141] `ami_preprocessing_scale` indicates which scaling should be applied to obtain the attenuation map sample values before applying them on the sample values of the associated video. Its value may have the following semantics:

- Value 0 specifies that a scaling of 1/255 should be applied.
- Value 1 specifies that a proprietary user-defined scaling operation is applied.

[0142] `ami_map_approx_model` specifies the model used to extrapolate the attenuation map with individual energy reduction rate to another set of attenuation map with a different energy reduction rate. The semantics of the values assigned to this field may be as follows:

- Value 0 specifies a linear scaling of the attenuation map sample values given its `ami_energy_reduction_rate` value.
- Value 1 specifies a bilinear interpolation between the attenuation map sample values given its `ami_energy_reduction_rate` value.
- Value 2 specifies an interpolation of type Lanczos is used with the attenuation map sample values given its `ami_energy_reduction_rate` value.

- Value 3 specifies that an interpolation of type bicubic between attenuation map sample values given its `ami_energy_reduction_rate` value.
- Value 4 specifies that a user-defined process is used to perform the approximation and infer the attenuation map sample values for different energy reduction rates.

5 **[0143]** `ami_window_x` indicates the x-coordinate of the top-left corner of the bounding window defining a region of the associated media video to apply the attenuation map carried by the display attenuation map track to.

10 **[0144]** `ami_window_y` indicates the x-coordinate of the top-left corner of the bounding window defining a region of the associated media video to apply the attenuation map carried by the display attenuation map track to.

15 **[0145]** `ami_window_width` indicates the width, in number of pixels, of the bounding window defining a region of the associated media video to apply the attenuation map carried by the display attenuation map track to.

20 **[0146]** `ami_window_height` indicates the height, in number of pixels, of the bounding window defining a region of the associated media video to apply the attenuation map carried by the display attenuation map track to.

25 **[0147]** `ami_quality_metric` indicates the type of the objective quality metric used for the measured quality reduction value resulting from applying the attenuation map to the video content and assigned to the `ami_quality_reduction` field. The semantics of the values assigned to this field may be as shown in Table 2.

Value	Quality Metric
0	PSNR
1	SSIM
2	wPSNR
3	WS-PSNR
4	User-defined

Table 2. Semantics of the values assigned to `ami_quality_metric`

30 **[0148]** `ami_quality_reduction` specifies the percentage of quality reduction in the media video as a result of applying the attenuation map to it.

[0149] In an example embodiment, attenuation maps are carried as timed-metadata tracks in an ISOBMFF container file. An attenuation map timed-metadata track may be a track with a newly defined sample entry (`AttenuationMapMetadataSampleEntry`) with the 4CC 'gamd' which extends `MetadataSampleEntry` (defined in ISO/IEC 14496-12) as shown in Table 3.

moov										container for all the movie data
	trak									container for an individual track or stream
		trgr								track grouping indication
		mdia								container for the media information in a track
			minf							media information container
				stbl						sample table box, container for the time/space map
					stsd					sample descriptions (codec types, initialization etc.)
						gamd				attenuation map metadata sample entry
							gami			attenuation map information

Table 3. Carrying Attenuation Maps as Timed-metadata Tracks.

[0150] In some embodiments, the `AttenuationMapMetadataSampleEntry` has the following syntax:

```
aligned(8) class AttenuationMapMetadataSampleEntry extends
    MetadataSampleEntry('gamd') {
    AttenuationMapInformationBox();
}
```

[0151] Each sample of the attenuation map metadata track carries coded video units for an attenuation map corresponding to a coded video frame in the associated video track.

[0152] In another embodiment, attenuation maps are carried as restricted video tracks in an ISOBMFF container file. Since these streams are not meant for direct rendering, restricted video schemes, as defined in subclause 8.15 of the ISO/IEC 14496-12 standard, can be used to signal post-decoder requirements on these tracks. This enables players to inspect the file and identify these requirements for rendering the bitstream and stops legacy players from decoding and rendering the attenuation map data. Tracks may be transformed into restricted video scheme tracks by setting their sample entry codes to the four-character code (4CC) 'resv' and adding a `RestrictedSchemeInfoBox` to their sample descriptions, while leaving all other boxes unmodified. The original sample entry type, which is based on the video codec used for encoding the stream, is then stored within an `OriginalFormatBox` within the `RestrictedSchemeInfoBox`. As defined in ISO/IEC 14496-12, the nature of the restriction may be

defined in the SchemeTypeBox, and the data needed for that scheme is stored in the SchemeInformationBox. These two boxes are stored within the RestrictedSchemeInfoBox. For attenuation map video stream tracks, the scheme_type field in SchemeTypeBox is set to 'gmat', indicating an *attenuation map restricted scheme*. The

5 SchemeInformationBox includes an AttenuationMapInformationBox, as described above. In the track header, the track_in_movie flag is set to 0, to indicate that this track should not be presented alone. Table 4 illustrates an arrangement for carrying attenuation maps as restricted video tracks.

moov										container for all the movie data
	trak									container for an individual track or stream
		trgr								track grouping indication
		mdia								container for the media information in a track
			minf							media information container
				stbl						sample table box, container for the time/space map
					std					sample descriptions (codec types, initialization etc.)
										sample entry or restricted sample entry
							rinf			restricted scheme info box
								fma		original format box
								schm		scheme type box
								schi		scheme information box
									gami	attenuation map information

Table 4. Carrying Attenuation Maps as Restricted Video Tracks

10 [0153] In another embodiment, attenuation maps are carried as auxiliary video tracks. An auxiliary video track is a video track whose handler_type field is set to 'vaux' in the HandlerBox of the MediaBox of the track to indicate that the track is not intended to be visually displayed. The sample entry of this auxiliary video track may include an AttenuationMapInformationBox as defined herein. In another embodiment, the auxiliary track is a restricted video track with a sample entry of type 'resv'

15 and includes a RestrictedSchemeInformationBox which includes a SchemeInformationBox which contains an AttenuationMapInformationBox as defined herein. In the track header, the track_in_movie flag is set to 0, to indicate that this track should not be presented alone.

[0154] In some embodiments, a TrackReferenceTypeBox with the reference type 'gmam'

20 may be added to a TrackReferenceBox within the TrackBox of the track carrying the attenuation

map data. The `TrackReferenceTypeBox` contains an array of `track_IDs` designating the identifiers for the referenced video tracks.

[0155] In another embodiment, the track reference type '`cdsc`', defined in ISO/IEC 14496-12 is used for the track reference to the associated video track.

5 **[0156]** In some embodiments, where the attenuation map stream is carried in an auxiliary video track, the track reference type '`auxl`', defined in ISO/IEC 14496-12 is used for the track reference to the associated video track.

[0157] In some embodiments, the track containing the video data may also have track references to the display attenuation map tracks associated with this track. In such embodiments, a
10 `TrackReferenceTypeBox` with the reference type designating this relationship (e.g., using the 4CC '`gmat`') is added to the `TrackReferenceBox` within the `TrackBox` of the video track. The `TrackReferenceTypeBox` shall also contain an array of `track_IDs` designating the identifiers for the referenced display attenuation map tracks.

[0158] In some embodiments, two or more alternative attenuation maps are available for the same video
15 track in the ISOBMFF container. These different attenuation maps may have, for example, different energy consumption levels, different video quality, or other different properties. Each attenuation map may have a separate attenuation map track. To signal that these tracks are alternatives to each other, in some embodiments, the alternate track mechanism defined in ISO/IEC 14496-12 is used. Attenuation map tracks that are alternatives of each other have identical values for the `alternate_group` field in their
20 respective `TrackHeaderBox(es)` in the ISOBMFF container.

[0159] In another embodiment, alternative display attenuation map tracks may be signaled by adding all the alternative tracks into a track group, as defined in ISO/IEC 14496-12, by adding a `TrackGroupBox` which includes an `AlternativeTrackGroupBox` to all these alternative attenuation map tracks. The `AlternativeTrackGroupBox` may have the following syntax.

25 `aligned(8) class AlternativeTrackGroupBox extends`
`TrackGroupBox('altr')`
`{`
`}`

[0160] In some embodiments, each sample in an attenuation map track carries a sequence of coded video
30 bitstream units corresponding to the encoded attenuation map for a single video frame in the associated

video track(s). In the case of attenuation maps encoded using an H.264/AVC, HEVC, and VVC video encoder, these coded video unit are network abstraction layer (NAL) units as defined in the ISO/IEC 14496-10, ISO/IEC 23008-2, and ISO/IEC 23090-3 specifications, respectively, and are encapsulated in the samples of the track based on the sample formats defined in ISO/IEC 14496-15 for these codecs.

- 5 **[0161]** Embodiment as described herein may be used in technological ecosystems involving sustainable or energy aware media coding, storage and streaming of the display attenuation map(s) and relative information associated with coded media content and supporting adaptive power consumption management on devices or any services providing video streaming and playback.

Example Delivery Systems and Methods

- 10 **[0162]** In some embodiments, a video together with its attenuation map (or maps) is stored in an ISOBMFF file and delivered to a client using a streaming mechanism such as dynamic adaptive streaming over HTTP (DASH).

- 15 **[0163]** FIG. 2 is a schematic illustration showing an example DASH system architecture according to some embodiments. Timed metadata tracks carrying Attenuation Map Information are signaled in the MPD Manifest file specified that enable delivery of continuous media content from standard HTTP servers to HTTP clients and enable caching of content by standard HTTP caches.

- 20 **[0164]** FIG. 2 illustrates an example of adaptive streaming system 200 based on DASH. The system includes a DASH server 206 and a DASH client 210. The server 206 is for example implemented through a content provider server, and a DASH client is for example implemented using a display device. When a DASH client 210 wishes to play multimedia content in adaptive streaming, it first gets a Media Presentation Description (MPD), a.k.a. a manifest, describing how this multimedia content might be obtained. This is generally done by getting the manifest from an URL (Uniform Resource Locator), for example through HTTP protocol as represented by the HTTP Cache 208 or by other means (e.g., broadcast, broadband service description, and so on). The manifest is generated in advance by the DASH media presentation description
- 25 202. The manifest may be static or may be updated dynamically. The manifest lists the available representations, also called instances or versions, of the multimedia content, with variations in terms of coding bitrate, image resolution, and other properties. A representation may be associated with a given quality level expressed as a bitrate. The data stream of each representation is provided by the DASH Segment delivery function 204 and is divided into segments (also called chunks) of equal duration (e.g., a
- 30 few seconds), accessible by a separate URL. The plurality of segments is prepared by the DASH Media Presentation Preparation. Different versions of each segment are prepared, ready to be provided to the

clients. When playing multiple content, a DASH client may smoothly switch from one quality level to another between two segments, to dynamically adapt to network conditions. When low bandwidth is available, a client requests low bitrate chunks and they may request higher bitrate chunks when higher bandwidth becomes available. As a result, the video quality may vary while playing but rarely suffers from interruptions (also called
5 freezes).

[0165] At the client side, the segments may be selected based on a measure of the available bandwidth of the transmission path. A DASH client usually requests the representation of a segment corresponding to a bitrate encoding and thus a quality compliant with the measured bandwidth.

[0166] FIG. 3 is a schematic illustration showing an example hierarchy for an MPD XML manifest file according to some embodiments. FIG. 3 illustrates an example structure 300 of Media Presentation Description 302 based on DASH. The Media Presentation Description 302 includes period elements 304, 312 (regular periods, early available periods, etc.) of equal length (60 seconds in the example), each of the period being identified by a Period ID, a start value representing the start time with respect to the first frame of the multimedia content of the period and a duration. Each period includes one or more adaptation sets 306,
15 314 which contain(s) alternate representations 308, 316 of the multimedia components considered to be perceptually equivalent. Adaptation set and the contained representations shall be prepared and contain sufficient information such that seamless switching across different representations in one adaptation set is possible. Multimedia content components being video, audio, teletext, subtitle, etc. Each representation 308, 316 includes a segment info 310, 318 that itself includes different sub-segments 320 having relative start time
20 with respect to the current segment. From one period to another, adaptation sets and the contained representations may be different.

[0167] For some embodiments, a mechanism for transmitting a pixel-wise attenuation map in an adaptive video streaming environment enables a receiver device to control its energy reduction rate when displaying the video. Some embodiments of an adaptation set for DASH may have an identifier (@id) attribute
25 that includes a string "ami", which stands for "Attenuation Map Information", for example, or that includes another string representing the notion of attenuation map signaling (e.g., "dm" for dimming map, "dpr" for display power reduction). This string is known by the DASH server and the DASH client. This identifier indicates that the adaptation set includes attenuation map information. Such an adaptation set enables a DASH MPD to list pixel-wise attenuation map representations available on the DASH server as different
30 representations. Such an adaptation set also enables a DASH client to select one of the representations to control its energy reduction rate when displaying the video. Instead of using the identifier @id="ami" to identify the new type of Adaptation Set Element, the attribute @contentType of an adaptation set may be set

to, for example, "Attenuation Map" or "am" or other strings to indicate the adaptation set element signals attenuation map representations. In the rest of this application, the term @id="ami" will be used for simplification.

[0168] A DASH client may also select multiple "ami" adaptation sets, for example identified by
5 @id="amiX", with X in the range 0..n, in the MPD manifest file, and therefore allow a selection of an appropriate attenuation map corresponding to a chosen energy reduction in which the adaptation sets have different values for the energy reduction. The same principle applies to the other parameters of the adaptation set. According to its energy consumption strategy, a DASH client may ignore the "ami" adaptation set. In this case, no pixel-wise attenuation map representation is requested by the DASH client,
10 and the video is displayed without any modification. As a result, the DASH client may not benefit from energy reduction.

[0169] For some embodiments, the "ami" adaptation set provides information on how to use the pixel-wise attenuation map representation, the type of displays on which to apply the attenuation map representation, the type of post-processing to further use the attenuation map representation, the type of downsampling and
15 its subsequent upsampling if any to apply as a preprocessing before using the attenuation map representation on an image, and some indicative metrics of the expected energy reduction and on the expected quality impact of the use of such an attenuation map representation.

[0170] For some embodiments, the "ami" adaptation set is dynamically updated within the DASH MPD per period and the granularity of the update may be based on time (per period/duration of the video content),
20 on temporal layers (per temporal layer), on slice type (per intra and inter slices) or on parts of the picture (Slices, Tiles, Sub-pictures). An MPD that includes an adaptation set with @id="ami" is hereafter named AMI-MPD. Such an MPD is generated at the DASH server, based on information provided by a processing block that handles the generation and encoding of the attenuation map from an input image. The AMI-MPD is parsed by a DASH client. In response, a pixel-wise attenuation map representation, for example
25 corresponding to a target reduction rate, is selected and requested by the DASH server. When received, the information from the adaptation set and the representations are provided to the media engine and to the post-processing module if required, to apply the selected attenuation map representation to the video component representation. This operation results in a reduced energy consumption of the DASH client because the image displayed uses less energy than the original image.

30 [0171] For some embodiments, multiple attenuation map representations are requested and are combined together. This operation allows a new attenuation map to be produced with an intermediate reduction rate, not directly available in the list of attenuation map representations. The new attenuation may

be generated by interpolating two attenuation map representations according to a weighting corresponding to the respective attenuation rates. In such an enhanced ecosystem, the DASH server and client are energy-aware devices in the sense that an energy-aware DASH server prepares data that are needed to allow an energy-aware DASH client to control its energy consumption through the selection, reception, and application of a pixel-wise dimming map.

[0172] The additional signaling enables a dash player to select a video media representation, one or several complementary attenuation maps (or dimming map), and one or several timed metadata representation(s) to modify the video and reduce the energy consumption while displaying the video on the screen of the receiver device or the screen connected to the receiver. A timed metadata representation may be associated with one or several attenuation map representation(s).

[0173] For some embodiments, a system may include an encoder, an origin server packager, and a decoder. The encoder is asked to create signal energy-related metadata into the bitstream. The decoder is asked to decode these metadata.

[0174] FIG. 4 is a schematic illustration showing an example video and attenuation map representation preparation at the server side according to some embodiments. In FIG. 4, the Input Video 402 is provisioned to the system 400 at the server side. The entity may handle the presentation preparation initiates and manage the following items:

- The encoding 404 of the different video component representations.
- The computing and the encoding of the attenuation maps 414, 416, 418, 420, 422, 424 with different energy reduction rates in the Map Computing and Encoding 406 entity.
- The creation of the Attenuation Map Information timed metadata and storage in an ISO Base Media File Format (ISOBMFF).
- The insertion in the MPD manifest file of the new kind of Adaptation Set and the attenuation map representations associated to the video representations.
- The insertion in the MPD manifest file of the Adaptation Set id="green video" and the Attenuation Map Information timed metadata Representations associated to the attenuation map representations.

[0175] The output(s) of the Encoding and Attenuation Map Computing block(s) 414, 416, 418, 420, 422, 424 is/are transmitted to the DASH delivery block 408, which may create the following segments of a media component:

- The segments of the different video representations (different bitrate, spatial resolution, frame rate, etc.),

- The segments of the attenuation maps representations.
- The segments of the Attenuation Map Information timed metadata representations.

[0176] The MPD manifest file is transmitted to the MPD delivery function to respond to any request from the DASH Client 412.

- 5 [0177] Segment formats may be based on ISOBMFF with fragmented movie files. (Sub)Segments are encoded as movie fragments containing a track fragment as defined in ISO/IEC 14496-12 with the constraints of being independently decodable.

[0178] The segments may be cached in an HTTP cache 410 for performance reasons. As for the segments of the multiple video representations, only the segments of the requested attenuation map representations and associated Attenuation Map Information timed metadata representations are available
10 in the cache for some embodiments. The DASH client requests the attenuation map representation depending on its energy reduction strategy from the information of the MPD manifest file (Attenuation Map Information timed metadata Representations).

[0179] FIG. 4 illustrates an example of architecture for an energy-aware DASH server according to an
15 embodiment. This architecture is for example implemented by a content provider server. The original input video is provisioned to the dash system to an encoding block that prepares and encodes the input video, splitting the video into segments and encoding the segments for the different video representations with for example different bitrates, different spatial resolutions, and/or different frame rates. The Map Generation module determines, from decoded images of these different video representations, a set of corresponding
20 attenuation maps, one attenuation map per decoded image. These maps are then conventionally encoded in so-called attenuation map representations using the same principle as for video segments. Multiple attenuation map representations may be used, for example with different energy reduction rates, as illustrated in the figure (one representation with 10% reduction, and a second representation with 20%). The DASH media presentation preparation module handles the preparation of the data used within the system
25 by driving the Encoding module and the Map Generation module, for example establishing the set of different bitrates, different spatial resolutions, and/or different frame rates for the different video representations as well as listing the reduction rates for which attenuation maps should be generated. The DASH media presentation preparation module then generates the MPD manifest file, that includes an adaptation set and the attenuation map representations, from metadata obtained from the Encoding module and the Map
30 Generation module. The metadata provides information for the element attributes of the adaptation set and representations (for example: energy reduction rate, usage of the attenuation map). The MPD manifest file is provided to the MPD delivery function to respond to requests from the DASH Client. The data generated

by the Encoding module and the Map Generation module are combined together by the DASH Segment delivery function to create the segments of the different video representations and the segments of the attenuation maps representations. These segments, including the video related segments and the corresponding attenuation map representations (e.g., 10% or 20% in the example of the figure), will then be
5 retrieved by a DASH client according to the information of the MPD manifest file and to a selected energy reduction strategy. As described below with respect to FIG. 5, the DASH client will then apply the attenuation to the video to generate an energy-aware image that will require less energy when being displayed on a screen than the original image.

[0180] The segments may be cached in an HTTP cache for performance reasons. This cache is handled
10 so that only the relevant segments of a selected video representation amongst the multiple video representations and only the segments of the selected attenuation map representations are available in the cache, thus ensuring a minimal load on the distribution network. Segment formats are based on ISO/BMFF with fragmented movie files, i.e. (Sub)Segments are encoded as movie fragments containing a track fragment as defined in ISO/IEC 14496-12 with the constraints of being independently decodable.

[0181] FIG. 5 is a schematic illustration showing example DASH client interfaces according to some embodiments. FIG. 5 shows an example DASH client architecture 500 with an ability to generate an attenuation map adaptation set. For some embodiments, video media and timed AMI metadata and AM
15 HTTP requests / segments may be exchanged between a DASH server 502 and a DASH access engine 506 via an HTTP cache 504.

[0182] FIG. 5 illustrates an example of architecture 500 for an energy-aware DASH client according to an embodiment. This architecture is for example implemented by a display device. FIG. 5 illustrates the logical components of a DASH client 508 and the relation to other components in a media streaming application. The DASH client 508 is operated under control of a Media Streaming Application 510. The DASH access engine 506 requests and receives from the server the Media Presentation Description (MPD) containing
25 information related to both Video Media component representations and the adaptation set with a list of attenuation map representations associated to the video media component representation. The energy reduction metadata are provided to the Selection Logic module. The energy reduction metadata includes information about the attenuation map representations, how to use them to reduce the energy consumption when the video component is presented on the display, the expected reduction rate and the associated
30 quality or experience metric. The Selection Logic module 512 may use the energy reduction metadata to select the media components of the service, requested by the Media Streaming application, through interactions with the energy consumption module. This module receives from the Media Streaming

application 510 the energy profile determined by the energy reduction strategy of the device itself or the End-user and provides the requested reduction rates to the Selection Logic module 512. Upon a selection of the representations, the Media Streaming application 510 configures the Decoding module 514 (e.g. codec, number of attenuation map representations, etc.), the attenuation map post-processing 516, the video and attenuation map application module 518, and the rendering module 520. Thus, the DASH access engine requests and receives the video media segments and the attenuation map representation segments corresponding to the selected representation. The attenuation map and the Video component representations are decoded by the decoding module. The attenuation map representations are optionally post-processed when needed (for example for up-scaling). The attenuation map representations are combined with the video by the application module 560 and the resulting video is rendered on the display by a video rendering module.

[0183] FIG. 5 illustrates the logical components of a conceptual DASH Client model and the relation to other components in a media streaming application. In this figure, the DASH access engine requests and receives the Media Presentation Description (MPD) containing both Video Media component representations, the attenuation map adaptation sets with a list of attenuation map representations associated to the video component representation and the green video adaptation sets with the list of the Attenuation Map Information timed metadata representations associated to the attenuation map representations, constructs and issues requests in relation with its energy reduction strategy and receives segments or parts of segments.

[0184] The DASH client may use the Attenuation Map Information timed metadata, retrieved from one or several representations of the green video adaptation sets associated to one or several attenuation maps, for the selection of the attenuation maps by communication with the media streaming application and the knowledge of the energy reduction strategy of the device itself or the end-user. The new Information relative to the current application may be provided and may include information about the attenuation maps and how to use them to reduce the energy consumption when the video component is presented on the display.

[0185] For some embodiments, the DASH access engine performs the following actions:

- Requests the Attenuation Map Information timed metadata representation segments.
- Retrieves the information relative to one or several attenuation maps.
- Decides whether the relative attenuation map(s) match(es) with the energy reduction strategy of the device or the end-user.
- Selects the attenuation map(s) and the video component(s).

- Outputs media and the maps in MPEG container formats or parts thereof, together with timing information that maps the internal timing of the continuous media to the timeline of the Media Presentation.

5 [0186] The attenuation map and video component representations are decoded, the attenuation map is applied, and the resulting video is rendered on the display.

[0187] FIG. 6A is a flowchart illustrating an example DASH server-side application process according to some embodiments. FIG. 6B is a flowchart illustrating an example DASH server-side application process according to some embodiments. These two example processes 600, 650 are very similar to each other. In FIG. 6A, energy reduction rates 622 are an input into the block computing and encoding an attenuation map (AM) 606. In FIG. 6B, a list of energy reduction rates 672 is used as an input, and for each energy reduction rate on the list, a looping process 674 may be performed. For some embodiments, an input video 624, 676 is used to encode 602, 652 a video frame. The output of the encoding may be processed via a default decoding block 604, 654 for each of these respective example processes 600, 650.

15 [0188] The attenuation map metadata 608, 658 used to create the adaptation set is used in the id to identify the type of the adaptation set element for the representations are generated 610, 660 while the attenuation map(s) is (are) computed 606, 656 by the Map Computing entity at the encoder side.

[0189] The new Adaptation Set which may have an identifier such as "ami" is inserted 612, 662 for a given period. The encoding of the picture by the Encoding entity is performed and results in a set of bitstreams with different characteristics (i.e., bitrate, resolution, ...). The bitstreams are decoded internally and the attenuation map corresponding to the picture is computed and encoded by the attenuation map Computing entity. Data about its use, its expected energy reduction and the corresponding expected quality are collected. These Information are gathered in the attenuation map Information timed metadata and inserted 614, 664 in the attenuation map Information sample entry and signaled in the Adaptation Set which may have id="green video" with of the MPD manifest file. The representations of this Adaptation Set are associated to the attenuation map representations. The Adaptation Sets are inserted 616, 666 in the MPD which is published 618, 668 by the MPD delivery function. Segments of the video component, the green video and attenuation map representations are transmitted 620, 670 to the DASH segment delivery function after being requested by the DASH client.

25 [0190] FIG. 7 is a flowchart illustrating an example DASH client-side process according to some embodiments.

[0191] FIG. 7 illustrates an example process for using an attenuation map representations according to an embodiment. Such a process 700 may be implemented by an energy-aware DASH client such as a display device. This process is for example implemented by a processor of such device. This process is for example initiated by the user that request streaming of a multimedia content.

5 [0192] Prior to this process, a target reduction rate has been selected. This selection may be done using different techniques. In an embodiment, the target reduction rate may be selected through a manual user operation by setting a numeric value for the target. For example, a slider may be displayed on the screen and controlled by the user to adjust a numerical value representing the target reduction rate. A numeric value may also be entered directly using digit keys on a keyboard.

10 [0193] In an embodiment, a list of potential target reduction rates may be displayed on the screen to allow the user to select one of the rates to become the target reduction rate. In an embodiment, the target reduction rate is selected through a configuration setting of the display device and obtained from the display device without requiring user intervention before displaying a multimedia content. Such configuration setting may be under control of the user, for example through a dedicated user interface.

15 [0194] In an embodiment, the target reduction rate is selected according to the category of multimedia content and based on a user configuration. The category may correspond to a classification, for example allowing to differentiate movies, news, advertisements, talk shows, music shows, etc. A user would be able to select using a dedicated user interface the target reduction rate for each category.

[0195] The DASH client requests 702 an MPD manifest file. After obtaining the MPD Manifest file, this file
20 is processed 704 to extract the necessary data to select the video component representation, the attenuation map representation(s), the parameters to configure the Decoding module, the attenuation maps post-processing module and the rendering modules. A request may be sent 706 and a response received for green video timed metadata. The DASH client checks 708 if the display model corresponding to the screen that will display the multimedia content is in the list of display models of the MPD. This is done by comparing
25 the display model (or type) information of the screen to the relevant parameter in the MPD.

[0196] In an example, the parameter in the MPD is set to 1 to indicate that the attenuation map representation should be used on an emissive display. If there is no match, for example for a first DASH client with a non-emissive display, the first DASH client requests 710 and receives representation segments for the video, decodes 712 the pictures of the video and provides the picture to the screen for being displayed.
30 The expected energy reduction will not be available for this first DASH client.

[0197] When there is a match, for example for a second DASH client with a non-emissive display and the parameter is set to 1, then the second DASH client will be able to benefit from an energy reduction allowed by the embodiments and will display an energy-reduced version of the multimedia content therefore lowering its energy consumption. In this case, the second DASH client requests 714 the attenuation map representation segment that corresponds to the selected target reduction rate, and receives it. The attenuation map representation is then decoded 716 and optionally preprocessed 718 and applied 720 to the decoded picture, according to the parameters of the Adaptation Set. For example, the attenuation map representation will be subsampled to reduce the quantity of data to be encoded. In this case, an upscaling is performed on the attenuation so that its resolution corresponds to the resolution of the image to be displayed. Independently (i.e., possibly at the same time or sequentially), the second DASH client requests 722 the video component representation segment, and receives it. The picture of the video component representation segment is then decoded 724. When both the attenuation map representation and corresponding picture have been decoded, the second DASH client sends 726 the reduced picture to be displayed. Compared to the display of the corresponding non-attenuated picture, the device will lower its energy consumption since the device displays an energy-reduced version of the picture.

[0198] Additionally, in the example where none of the available Attenuation Map representations proposes the target energy reduction rate selected by the user, the device will select one of the available attenuation map representations and perform an interpolation of the attenuation map representation values to obtain the selected target energy reduction rate. The selection is done by choosing for example the attenuation with closest reduction rate with regards to the selected target reduction rate. In the case where the selected target energy reduction rate is between two available target energy reduction rates, then request, receive, and decode the attenuation map representations corresponding to these two reduction rates to be able to perform an interpolation between their values. For example, when the user selected a 30% reduction rate and the available attenuation map representations have reduction rates of 20% and 40%, then these two maps will be interpolated by simply taking the average values.

[0199] In an embodiment, the DASH client is not in an energy consumption reduction mode and therefore does not consider the "ami" Adaptation Set and the attached attenuation map representations. Only the video component representation segments are requested.

[0200] Several embodiments may be envisioned for the use of the attenuation map and its accompanying metadata. FIG. 7 depicts a block diagram of the MPD usage by an end device, containing a display compatible with an amiDisplayModel parameter, according to an embodiment to apply a green strategy by using the attenuation maps.

- 5 [0201] FIG. 8 is a schematic illustration showing an example DASH client-side process according to some embodiments. For some embodiments of such a process 800, an MPD file 808 is received as well as data 810 for multiple segments by a DASH access engine 804. A selection is made. The DASH access engine 804 may send MPD selection metadata 812, which may include a new adaptation set, to a selection logic process 802. The selection process 802 may send 814 an indication back to the DASH access engine indicating the selected representations for AMI time metadata, video, and attenuation maps. The DASH access engine 804 may send 816 MPEG format video media, attenuation maps, and timing information to a media engine 806. The media engine 806 may use this received data to generate and/or display reduced energy video media.
- 10 [0202] FIG. 9 is a flowchart illustrating an example process for handling an attenuation map according to some embodiments. For some embodiments, an example process 900 may include obtaining 902 a container file, wherein the container file includes: at least one video track representing an encoded video, and a first attenuation map track representing a first attenuation map data stream, the first attenuation map track including a first information box characterizing the first attenuation map data stream.
- 15 [0203] FIG. 10 is a flowchart illustrating an example process for handling an attenuation map according to some embodiments. For some embodiments, an example process 1000 may include obtaining 1002 a container file, wherein the container file includes: at least one video track representing an encoded video, and a first attenuation map track representing a first attenuation map data stream, the first attenuation map track including a first information box characterizing the first attenuation map data stream. For some
- 20 embodiments, the example process 1000 may further include, at a decoder, decoding 1004 the video track to obtain a decoded video. For some embodiments, the example process 1000 may further include, at a decoder: decoding 1006 the first attenuation map track to obtain a decoded attenuation map. For some embodiments, the example process 1000 may further include, at a decoder, applying 1008 the decoded attenuation map to the decoded video to obtain an attenuated video.
- 25 [0204] An example apparatus in accordance with some embodiments may include at least one processor configured to perform any one of the methods described within this application. An example apparatus in accordance with some embodiments may include a computer-readable medium storing instructions for causing one or more processors to perform any one of the methods described within this application. An example apparatus in accordance with some embodiments may include at least one processor and at least
- 30 one non-transitory computer-readable medium storing instructions for causing the at least one processor to perform any one of the methods described within this application. An example signal in accordance with

some embodiments may include a bitstream generated according to any one of the methods described within this application.

[0205] While the methods and systems in accordance with some embodiments are generally discussed in context of extended reality (XR), some embodiments may be applied to any XR contexts such as, e.g.,
5 virtual reality (VR) / mixed reality (MR) / augmented reality (AR) contexts. Also, although the term "head mounted display (HMD)" is used herein in accordance with some embodiments, some embodiments may be applied to a wearable device (which may or may not be attached to the head) capable of, e.g., XR, VR, AR, and/or MR for some embodiments.

[0206] A first example method in accordance with some embodiments may include: obtaining a container
10 file, wherein the container file includes: at least one video track representing an encoded video, and a first attenuation map track representing a first attenuation map data stream, the first attenuation map track including a first information box characterizing the first attenuation map data stream.

[0207] For some embodiments of the first example method, the first information box identifies first pre-processing operations to be applied to samples of the first attenuation map stream.

15 [0208] For some embodiments of the first example method, the first information box identifies a first energy reduction rate associated with the first attenuation map data stream.

[0209] For some embodiments of the first example method, the first information box identifies a first quality reduction associated with the first attenuation map data stream.

[0210] For some embodiments of the first example method, the first information box identifies a first set
20 of color components to which the first attenuation map data stream is to be applied.

[0211] For some embodiments of the first example method, the first attenuation map track is a timed-metadata track.

[0212] For some embodiments of the first example method, the first attenuation map track includes a plurality of samples, and each sample carries coded video units for an attenuation map corresponding to a
25 coded video frame in the video track.

[0213] For some embodiments of the first example method, the first attenuation map track is a restricted video track.

[0214] For some embodiments of the first example method, the first information box is stored in a first restricted scheme information box.

[0215] For some embodiments of the first example method, the first attenuation map track is an auxiliary video track.

[0216] For some embodiments of the first example method, the first attenuation map track includes a track reference type box, and wherein the track reference type box includes a track identifier identifying at least one of the video tracks.

[0217] For some embodiments of the first example method, at least one of the video tracks includes a track reference type box, and wherein the track reference type box includes a track identifier identifying the first attenuation map track.

[0218] For some embodiments of the first example method, the container file includes a plurality of attenuation map tracks including the first attenuation map track, each of the attenuation map tracks including a track header box, and wherein a plurality of the attenuation map tracks have identical values of an alternative group field in their respective track header boxes.

[0219] For some embodiments of the first example method, the container file includes a plurality of attenuation map tracks including the first attenuation map track, and wherein each of the attenuation map tracks includes a track group box associating the plurality of attenuation map tracks into a track group.

[0220] Some embodiments of the first example method may further include, at a decoder: decoding the video track to obtain a decoded video; decoding the first attenuation map track to obtain a decoded attenuation map; and applying the decoded attenuation map to the decoded video to obtain an attenuated video.

[0221] For some embodiments of the first example method, the decoded attenuation map is applied to the decoded video according to information in the first information box.

[0222] Some embodiments of the first example method may further include displaying the attenuated video.

[0223] Some embodiments of the first example method may further include, at a server: based on information received from a client, selecting the first attenuation map track from among a plurality of attenuation map tracks in the container file; and streaming the video track and the first attenuation map track to the client.

[0224] For some embodiments of the first example method, the first attenuation map track is selected based on information in the first information box.

[0225] For some embodiments of the first example method, the first attenuation map track is selected based on the first energy reduction rate associated with the first attenuation map data stream.

[0226] For some embodiments of the first example method, the first attenuation map track is selected based on the first quality reduction associated with the first attenuation map data stream.

5 [0227] For some embodiments of the first example method, the container file is an ISOBMFF file.

[0228] A first example apparatus in accordance with some embodiments may include: a processor; and a non-transitory computer-readable medium storing instructions operative, when executed by the processor, to cause the apparatus to perform any one of the methods listed above.

10 [0229] A second example apparatus in accordance with some embodiments may include at least one processor configured to perform any one of the methods listed above.

[0230] A third example apparatus in accordance with some embodiments may include a computer-readable medium storing instructions for causing one or more processors to perform any one of the methods listed above.

15 [0231] A fourth example apparatus in accordance with some embodiments may include: at least one processor and at least one non-transitory computer-readable medium storing instructions for causing the at least one processor to perform any one of the methods listed above.

20 [0232] A first example computer-readable medium storing a container file in accordance with some embodiments, wherein the container file may include: at least one video track representing an encoded video, and a first attenuation map track representing a first attenuation map data stream, the first attenuation map track including a first information box characterizing the first attenuation map data stream.

[0233] A second example computer-readable medium storing a container file in accordance with some embodiments, wherein the container file may include: at least one video track representing an encoded video, and a first attenuation map track representing a first attenuation map data stream, the first attenuation map track including a first information box characterizing the first attenuation map data stream.

25 [0234] For some embodiments of the second example computer-readable medium, the first information box identifies first pre-processing operations to be applied to samples of the first attenuation map stream.

[0235] For some embodiments of the second example computer-readable medium, the first information box identifies a first energy reduction rate associated with the first attenuation map data stream.

30 [0236] For some embodiments of the second example computer-readable medium, the first information box identifies a first quality reduction associated with the first attenuation map data stream.

[0237] For some embodiments of the second example computer-readable medium, the first information box identifies a first set of color components to which the first attenuation map data stream is to be applied.

[0238] For some embodiments of the second example computer-readable medium, the first attenuation map track is a timed-metadata track.

- 5 [0239] For some embodiments of the second example computer-readable medium, the first attenuation map track includes a plurality of samples, and wherein each sample carries coded video units for an attenuation map corresponding to a coded video frame in the video track.

[0240] For some embodiments of the second example computer-readable medium, the first attenuation map track is a restricted video track.

- 10 [0241] For some embodiments of the second example computer-readable medium, the first information box is stored in a first restricted scheme information box.

[0242] For some embodiments of the second example computer-readable medium, the first attenuation map track is an auxiliary video track.

- [0243] For some embodiments of the second example computer-readable medium, the first attenuation
15 map track includes a track reference type box, and wherein the track reference type box includes a track identifier identifying at least one of the video tracks.

[0244] For some embodiments of the second example computer-readable medium, at least one of the video tracks includes a track reference type box, and wherein the track reference type box includes a track identifier identifying the first attenuation map track.

- 20 [0245] For some embodiments of the second example computer-readable medium, the container file includes a plurality of attenuation map tracks including the first attenuation map track, each of the attenuation map tracks including a track header box, and wherein a plurality of the attenuation map tracks have identical values of an alternative group field in their respective track header boxes.

- [0246] For some embodiments of the second example computer-readable medium, the container file
25 includes a plurality of attenuation map tracks including the first attenuation map track, and wherein each of the attenuation map tracks includes a track group box associating the plurality of attenuation map tracks into a track group.

[0247] For some embodiments of the second example computer-readable medium, the container file is an ISOBMFF file.

[0248] A method according to some embodiments comprises obtaining a container file, wherein the container file includes: at least one video track representing an encoded video, and a first attenuation map track representing a first attenuation map data stream, the first attenuation map track including a first information box characterizing the first attenuation map data stream.

5 **[0249]** In some embodiments, includes some or all of the following information: first pre-processing operations to be applied to samples of the first attenuation map stream, a first energy reduction rate associated with the first attenuation map data stream, a first quality reduction associated with the first attenuation map data stream, or a first set of color components to which the first attenuation map data stream is to be applied.

10 **[0250]** In some embodiments, the first attenuation map track is a timed-metadata track. In such embodiments, the first attenuation map track may include a plurality of samples, and each sample may carry coded video units for an attenuation map corresponding to a coded video frame in the video track.

[0251] In some embodiments, the first attenuation map track is a restricted video track.

15 **[0252]** In some embodiments, the first information box is stored in a first restricted scheme information box.

[0253] In some embodiments, the first attenuation map track is an auxiliary video track.

[0254] In some embodiments, the first attenuation map track includes a track reference type box, and wherein the track reference type box includes a track identifier identifying at least one of the video tracks.

20 **[0255]** In some embodiments, at least one of the video tracks includes a track reference type box, and the track reference type box includes a track identifier identifying the first attenuation map track.

[0256] In some embodiments, the container file includes a plurality of attenuation map tracks including the first attenuation map track, each of the attenuation map tracks including a track header box, and a plurality of the attenuation map tracks have identical values of an alternative group field in their respective track header boxes.

25 **[0257]** In some embodiments, the container file includes a plurality of attenuation map tracks including the first attenuation map track, and each of the attenuation map tracks includes a track group box associating the plurality of attenuation map tracks into a track group.

[0258] Some methods include embodiments performed by encoders, decoders, clients, and servers making use of container files as described herein.

[0259] In some embodiments, a container file according to any of the embodiments described herein is obtained by a decoder. The decoder performs at least: decoding the video track to obtain a decoded video; decoding the first attenuation map track to obtain a decoded attenuation map; and applying the decoded attenuation map to the decoded video to obtain an attenuated video. In some embodiments, the decoded
5 attenuation map is applied to the decoded video according to information in the first information box. Some embodiments further include displaying the attenuated video.

[0260] In some embodiments, a container file according to any of the embodiments described herein is obtained by a server. The server performs at least: based on information received from a client, selecting the first attenuation map track from among a plurality of attenuation map tracks in the container file; and
10 streaming the video track and the first attenuation map track to the client.

[0261] In some embodiments, the first attenuation map track is selected based on information in the first information box. For example, the first attenuation map track may be selected at least in part based on the first energy reduction rate associated with the first attenuation map data stream. The first attenuation map track may be selected based at least in part on the first quality reduction associated with the first attenuation
15 map data stream, and/or other factors. In some embodiments, the container file is an ISOBMFF file.

[0262] In some embodiments an encoder encodes at least one video and at least one attenuation map in a container file as described in any of the embodiments herein.

[0263] An apparatus according to some embodiments comprises: a processor; and a non-transitory computer-readable medium storing instructions operative, when executed by the processor, to cause the
20 apparatus to perform any of the methods described herein.

[0264] An apparatus according to some embodiments comprises at least one processor configured to perform any of the methods described herein.

[0265] Some embodiments include a computer-readable medium storing instructions for causing one or more processors to perform any of the methods described herein.

25 Further Embodiments

[0266] This disclosure describes a variety of aspects, including tools, features, embodiments, models, approaches, etc. Many of these aspects are described with specificity and, at least to show the individual characteristics, are often described in a manner that may sound limiting. However, this is for purposes of clarity in description, and does not limit the disclosure or scope of those aspects. Indeed, all of the different
30 aspects can be combined and interchanged to provide further aspects. Moreover, the aspects can be combined and interchanged with aspects described in earlier filings as well.

[0267] The aspects described and contemplated in this disclosure can be implemented in many different forms. While some embodiments are illustrated specifically, other embodiments are contemplated, and the discussion of particular embodiments does not limit the breadth of the implementations. At least one of the aspects generally relates to encoding and decoding, and at least one other aspect generally relates to transmitting a bitstream generated or encoded. These and other aspects can be implemented as a method, an apparatus, a computer readable storage medium having stored thereon instructions for encoding or decoding data according to any of the methods described, and/or a computer readable storage medium having stored thereon a bitstream generated according to any of the methods described.

[0268] Various methods are described herein, and each of the methods comprises one or more steps or actions for achieving the described method. Unless a specific order of steps or actions is required for proper operation of the method, the order and/or use of specific steps and/or actions may be modified or combined. Additionally, terms such as "first", "second", etc. may be used in various embodiments to modify an element, component, step, operation, etc., such as, for example, a "first decoding" and a "second decoding". Use of such terms does not imply an ordering to the modified operations unless specifically required. So, in this example, the first decoding need not be performed before the second decoding, and may occur, for example, before, during, or in an overlapping time period with the second decoding.

[0269] Various numeric values may be used in the present disclosure, for example. The specific values are for example purposes and the aspects described are not limited to these specific values.

[0270] Embodiments described herein may be carried out by computer software implemented by a processor or other hardware, or by a combination of hardware and software. As a non-limiting example, the embodiments can be implemented by one or more integrated circuits. The processor can be of any type appropriate to the technical environment and can encompass one or more of microprocessors, general purpose computers, special purpose computers, and processors based on a multi-core architecture, as non-limiting examples.

[0271] Various implementations involve decoding. "Decoding", as used in this disclosure, can encompass all or part of the processes performed, for example, on a received encoded sequence in order to produce a final output suitable for presentation. In various embodiments, such processes include one or more of the processes typically performed by a decoder, for example, entropy decoding, inverse quantization, inverse transformation, and differential decoding. In various embodiments, such processes also, or alternatively, include processes performed by a decoder of various implementations described in this disclosure.

[0272] Various implementations involve encoding. In an analogous way to the above discussion about "decoding", "encoding" as used in this disclosure can encompass all or part of the processes performed, for

example, on an input in order to produce an encoded bitstream. In various embodiments, such processes include one or more of the processes typically performed by an encoder, for example, partitioning, differential encoding, transformation, quantization, and entropy encoding. In various embodiments, such processes also, or alternatively, include processes performed by an encoder of various implementations described in this disclosure.

[0273] When a figure is presented as a flow diagram, it should be understood that it also provides a block diagram of a corresponding apparatus. Similarly, when a figure is presented as a block diagram, it should be understood that it also provides a flow diagram of a corresponding method/process.

[0274] The implementations and aspects described herein can be implemented in, for example, a method or a process, an apparatus, a software program, a data stream, or a signal. Even if only discussed in the context of a single form of implementation (for example, discussed only as a method), the implementation of features discussed can also be implemented in other forms (for example, an apparatus or program). An apparatus can be implemented in, for example, appropriate hardware, software, and firmware. The methods can be implemented in, for example, a processor, which refers to processing devices in general, including, for example, a computer, a microprocessor, an integrated circuit, or a programmable logic device. Processors also include communication devices, such as, for example, computers, cell phones, portable/personal digital assistants ("PDAs"), and other devices that facilitate communication of information between end-users.

[0275] Reference to "one embodiment" or "an embodiment" or "one implementation" or "an implementation", as well as other variations thereof, means that a particular feature, structure, characteristic, and so forth described in connection with the embodiment is included in at least one embodiment. Thus, the appearances of the phrase "in one embodiment" or "in an embodiment" or "in one implementation" or "in an implementation", as well as any other variations, appearing in various places throughout this disclosure are not necessarily all referring to the same embodiment.

[0276] Additionally, this disclosure may refer to "determining" various pieces of information. Determining the information can include one or more of, for example, estimating the information, calculating the information, predicting the information, or retrieving the information from memory.

[0277] Further, this disclosure may refer to "accessing" various pieces of information. Accessing the information can include one or more of, for example, receiving the information, retrieving the information (for example, from memory), storing the information, moving the information, copying the information, calculating the information, determining the information, predicting the information, or estimating the information.

[0278] Additionally, this disclosure may refer to "receiving" various pieces of information. Receiving is, as with "accessing", intended to be a broad term. Receiving the information can include one or more of, for example, accessing the information, or retrieving the information (for example, from memory). Further, "receiving" is typically involved, in one way or another, during operations such as, for example, storing the information, processing the information, transmitting the information, moving the information, copying the information, erasing the information, calculating the information, determining the information, predicting the information, or estimating the information.

[0279] It is to be appreciated that the use of any of the following "I", "and/or", and "at least one of", for example, in the cases of "A/B", "A and/or B" and "at least one of A and B", is intended to encompass the selection of the first listed option (A) only, or the selection of the second listed option (B) only, or the selection of both options (A and B). As a further example, in the cases of "A, B, and/or C" and "at least one of A, B, and C", such phrasing is intended to encompass the selection of the first listed option (A) only, or the selection of the second listed option (B) only, or the selection of the third listed option (C) only, or the selection of the first and the second listed options (A and B) only, or the selection of the first and third listed options (A and C) only, or the selection of the second and third listed options (B and C) only, or the selection of all three options (A and B and C). This may be extended for as many items as are listed.

[0280] Also, as used herein, the word "signal" refers to, among other things, indicating something to a corresponding decoder. For example, in certain embodiments the encoder signals a particular one of a plurality of parameters for region-based filter parameter selection for de-artifact filtering. In this way, in an embodiment the same parameter is used at both the encoder side and the decoder side. Thus, for example, an encoder can transmit (explicit signaling) a particular parameter to the decoder so that the decoder can use the same particular parameter. Conversely, if the decoder already has the particular parameter as well as others, then signaling can be used without transmitting (implicit signaling) to simply allow the decoder to know and select the particular parameter. By avoiding transmission of any actual functions, a bit savings is realized in various embodiments. It is to be appreciated that signaling can be accomplished in a variety of ways. For example, one or more syntax elements, flags, and so forth are used to signal information to a corresponding decoder in various embodiments. While the preceding relates to the verb form of the word "signal", the word "signal" can also be used herein as a noun.

[0281] Implementations can produce a variety of signals formatted to carry information that can be, for example, stored or transmitted. The information can include, for example, instructions for performing a method, or data produced by one of the described implementations. For example, a signal can be formatted to carry the bitstream of a described embodiment. Such a signal can be formatted, for example, as an

electromagnetic wave (for example, using a radio frequency portion of spectrum) or as a baseband signal. The formatting can include, for example, encoding a data stream and modulating a carrier with the encoded data stream. The information that the signal carries can be, for example, analog or digital information. The signal can be transmitted over a variety of different wired or wireless links, as is known. The signal can be stored on a processor-readable medium.

[0282] We describe a number of embodiments. Features of these embodiments can be provided alone or in any combination, across various claim categories and types.

[0283] Note that various hardware elements of one or more of the described embodiments are referred to as “modules” that carry out (i.e., perform, execute, and the like) various functions that are described herein in connection with the respective modules. As used herein, a module includes hardware (e.g., one or more processors, one or more microprocessors, one or more microcontrollers, one or more microchips, one or more application-specific integrated circuits (ASICs), one or more field programmable gate arrays (FPGAs), one or more memory devices) deemed suitable for a given implementation. Each described module may also include instructions executable for carrying out the one or more functions described as being carried out by the respective module, and it is noted that those instructions could take the form of or include hardware (i.e., hardwired) instructions, firmware instructions, software instructions, and/or the like, and may be stored in any suitable non-transitory computer-readable medium or media, such as commonly referred to as RAM, ROM, etc.

[0284] Although features and elements are described above in particular combinations, each feature or element can be used alone or in any combination with the other features and elements. In addition, the methods described herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, RNC, or any host computer.

CLAIMS

1. A method comprising:
 - obtaining a container file, wherein the container file includes:
 - at least one video track representing an encoded video, and
 - 5 a first attenuation map track representing a first attenuation map data stream, the first attenuation map track including a first information box characterizing the first attenuation map data stream.
2. The method of claim 1, wherein the first information box identifies first pre-processing operations to be applied to samples of the first attenuation map stream.
- 10 3. The method of any of claim 1-2, wherein the first information box identifies a first energy reduction rate associated with the first attenuation map data stream.
4. The method of any of claims 1-3, wherein the first information box identifies a first quality reduction associated with the first attenuation map data stream.
5. The method of any of claims 1-4, wherein the first information box identifies a first set of color components
- 15 to which the first attenuation map data stream is to be applied.
6. The method of any of claims 1-5, wherein the first attenuation map track is a timed-metadata track.
7. The method of claim 6,
 - wherein the first attenuation map track includes a plurality of samples, and
 - wherein each sample carries coded video units for an attenuation map corresponding to a coded
 - 20 video frame in the video track.
8. The method of any of claims 1-5, wherein the first attenuation map track is a restricted video track.
9. The method of claim 8, wherein the first information box is stored in a first restricted scheme information box.
10. The method of any of claims 1-5, wherein the first attenuation map track is an auxiliary video track.
- 25 11. The method of any of claims 1-10, wherein the first attenuation map track includes a track reference type box, and wherein the track reference type box includes a track identifier identifying at least one of the video tracks.

12. The method of any of claims 1-11, wherein at least one of the video tracks includes a track reference type box, and wherein the track reference type box includes a track identifier identifying the first attenuation map track.
13. The method of any of claims 1-12, wherein the container file includes a plurality of attenuation map tracks including the first attenuation map track, each of the attenuation map tracks including a track header box, and wherein a plurality of the attenuation map tracks have identical values of an alternative group field in their respective track header boxes.
14. The method of any of claims 1-13, wherein the container file includes a plurality of attenuation map tracks including the first attenuation map track, and wherein each of the attenuation map tracks includes a track group box associating the plurality of attenuation map tracks into a track group.
15. The method of any of claims 1-14, further comprising, at a decoder:
decoding the video track to obtain a decoded video;
decoding the first attenuation map track to obtain a decoded attenuation map; and
applying the decoded attenuation map to the decoded video to obtain an attenuated video.
16. The method of claim 15, wherein the decoded attenuation map is applied to the decoded video according to information in the first information box.
17. The method of any of claims 15-16, further comprising displaying the attenuated video.
18. The method of any of claims 1-14, further comprising, at a server:
based on information received from a client, selecting the first attenuation map track from among a plurality of attenuation map tracks in the container file; and
streaming the video track and the first attenuation map track to the client.
19. The method of claim 18, wherein the first attenuation map track is selected based on information in the first information box.
20. The method of claim 18 or 19, wherein the first attenuation map track is selected based on the first energy reduction rate associated with the first attenuation map data stream.
21. The method of any of claims 18-20, wherein the first attenuation map track is selected based on the first quality reduction associated with the first attenuation map data stream.

22. The method of any of claims 1-21, wherein the container file is an ISOBMFF file.
23. An apparatus comprising:
a processor; and
a non-transitory computer-readable medium storing instructions operative, when executed by the
5 processor, to cause the apparatus to perform the method of any of claims 1-22.
24. An apparatus comprising at least one processor configured to perform the method of any one of claims 1-22.
25. An apparatus comprising a computer-readable medium storing instructions for causing one or more processors to perform the method of any one of claims 1-22.
- 10 26. An apparatus comprising at least one processor and at least one non-transitory computer-readable medium storing instructions for causing the at least one processor to perform the method of any one of claims 1-22.
27. A computer-readable medium storing a container file, wherein the container file includes:
at least one video track representing an encoded video, and
15 a first attenuation map track representing a first attenuation map data stream, the first attenuation map track including a first information box characterizing the first attenuation map data stream.
28. A computer-readable medium storing a container file, wherein the container file includes:
at least one video track representing an encoded video, and
a first attenuation map track representing a first attenuation map data stream, the first attenuation
20 map track including a first information box characterizing the first attenuation map data stream.
29. The computer-readable medium of claim 28, wherein the first information box identifies first pre-processing operations to be applied to samples of the first attenuation map stream.
30. The computer-readable medium of any of claim 28-29, wherein the first information box identifies a first energy reduction rate associated with the first attenuation map data stream.
- 25 31. The computer-readable medium of any of claims 28-30, wherein the first information box identifies a first quality reduction associated with the first attenuation map data stream.

32. The computer-readable medium of any of claims 28-31, wherein the first information box identifies a first set of color components to which the first attenuation map data stream is to be applied.
33. The computer-readable medium of any of claims 28-32, wherein the first attenuation map track is a timed-metadata track.
- 5 34. The computer-readable medium of claim 33, wherein the first attenuation map track includes a plurality of samples, and wherein each sample carries coded video units for an attenuation map corresponding to a coded video frame in the video track.
35. The computer-readable medium of any of claims 28-32, wherein the first attenuation map track is a restricted video track.
- 10 36. The computer-readable medium of claim 35, wherein the first information box is stored in a first restricted scheme information box.
37. The computer-readable medium of any of claims 28-32, wherein the first attenuation map track is an auxiliary video track.
- 15 38. The computer-readable medium of any of claims 28-37, wherein the first attenuation map track includes a track reference type box, and wherein the track reference type box includes a track identifier identifying at least one of the video tracks.
39. The computer-readable medium of any of claims 28-38, wherein at least one of the video tracks includes a track reference type box, and wherein the track reference type box includes a track identifier identifying the first attenuation map track.
- 20 40. The computer-readable medium of any of claims 28-39, wherein the container file includes a plurality of attenuation map tracks including the first attenuation map track, each of the attenuation map tracks including a track header box, and wherein a plurality of the attenuation map tracks have identical values of an alternative group field in their respective track header boxes.
- 25 41. The computer-readable medium of any of claims 28-40, wherein the container file includes a plurality of attenuation map tracks including the first attenuation map track, and wherein each of the attenuation map tracks includes a track group box associating the plurality of attenuation map tracks into a track group.

42. The computer-readable medium of any of claims 28-41, wherein the container file is an ISOBMFF file.