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TV Architecture Supporting Multiple 3D Services

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I. INTRODUCTION

There is a growing interest in delivery of 3D content to the home. Production of 3D cinema content is steadily increasing, and there are already devices supporting stereoscopic display available to the consumer. To facilitate interoperable services to the home, standards for production distribution and digital interfaces are being developed or amended.

Digital televisions (DTV) have traditionally been designed to accept as input uncompressed content from other receivers or sources as well as terrestrial broadcast services. In recent years, there is an increased number of services that the DTV is expected to handle (e.g., from cable or Internet) and sources of uncompressed content (e.g., from gaming consoles or optical disc players). Additionally, the DTV architecture will also need to be augmented to handle 3D content as well, both compressed and uncompressed formats. We make a distinction between two classes of DTV devices:

- 3D-Ready TV: can identify uncompressed 3D content, properly process and display a standard 3D image/video format.
- 3D-Capable TV: can identify compressed 3D content, properly decode, process and display a standard 3D distribution format; this class of TV may simply be referred to as 3D TV in the future.

There are already 3D-Ready displays in the market with certain capabilities. These capabilities will be briefly reviewed and issues on making these devices compatible with new services will be discussed. The migration to 3D-Capable devices will also be considered. New 3D display processing capabilities will also be addressed.

II. SYSTEM ARCHITECTURE

A high-level overview the TV architecture including receiving and display processing components that supports multiple 2D and 3D services is shown in Figure 1. There exist various sources of uncompressed content originating from external devices such as Blu-ray Disc players, gaming consoles, and set-top boxes associated with cable, satellite or IPTV services. The connection from these devices to the TV is typically through HDMI or another uncompressed digital interface. The system is also designed to accept compressed video associated with terrestrial broadcast or cable services. Additionally, the TV may also consider support of Internet content that is streamed from an external server directly to the home.

The system is partitioned into five sections including the RF front-end, demodulation, 2D/3D decoder, 2D/3D audio-visual (A/V) processor and 2D/3D display. Additionally, a micro-processor operating the necessary software controls the overall operation of all sections. In the following, we focus on the decoder, A/V processor and display functionality in the context of both 3D-Ready and 3D-Capable TVs.

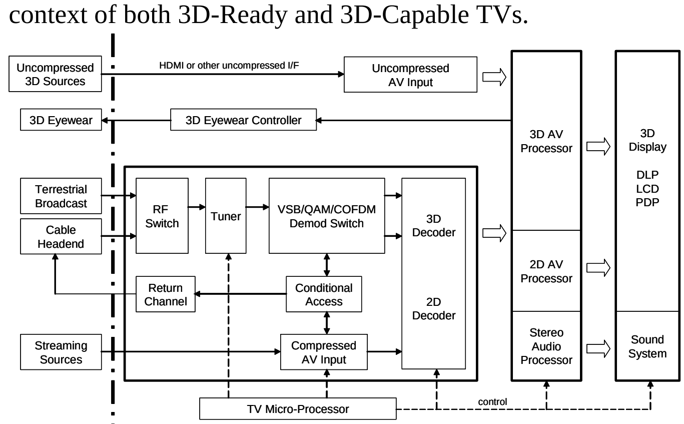

Figure 1. Block diagram of TV architecture supporting multiple 3D services and content sources.

III. 3D-READY TV

As defined earlier, 3D-Ready TVs are capable of accepting as input an uncompressed format of a stereoscopic video signal and rendering it. While it is expected that future 3D-Ready TV's will be capable of processing multiple uncompressed 3D input formats, there are a few issues that need to be addressed to ensure that legacy devices that do not support a multitude of formats beyond their native display capability could still be utilized in the context of new 3D services.

The first issue is that the first generation of 3D-Ready TVs that entered the market only support a limited set of input video formats. In most cases, only the native display format would be supported, e.g., checkerboard for DLP-based devices or line interleaving for some LCD-based devices. Therefore, in order for these TVs to operate in a 3D mode, the source material must be delivered in the native display format. This could be accomplished in one of two ways.

One way is to ensure that service (or source) provides a 3D format that exactly matches the display capabilities. However, with multiple native formats in different types of displays, this might be impossible to achieve in practice. In general, it should be assumed that the service format is different than that of the native display format in most cases.

An alternative would be to perform a conversion between the format associated with a particular service and the native display format. This would either place an additional burden on the source to perform the necessary conversion, or would require an external conversion box as an interface between the source and the 3D-Ready TV. When the two formats have different sub-sampling structures, the quality of the conversion needs to be considered. Moreover, since there are only a few native 3D display formats supported in 3D-Ready TVs today and it is not very difficult to perform conversion to these formats by sources, a new 3D video service could be promoted with already existing 3D-Ready TV products.

The second major issue is that existing 3D-Ready TVs typically support an interface that was not specifically designed for 3D, e.g., HDMI v1.3. While such interfaces are capable of supporting the required bandwidth for a wide variety of 3D formats, there is no signaling in place to identify the format being sent. To rectify this situation, modifications to the existing interface specifications would need to be made. The changes should be minor so that existing devices could be upgraded with a relatively simple firmware update. The main functionality enabled would be to identify the format of the content so that the content could be correctly displayed.

There are ongoing discussions within CEA and other standards development organizations responsible for delivery of 3D content to the home to address the above concerns [1]. Solutions are certainly needed to ensure that these legacy devices that fueled initial momentum towards defining 3D services are not alienated as 3D services become available through different distribution channels.

IV. 3D-CAPABLE TV

TVs that are 3D-Capable accept as input compressed streams carrying 3D (stereoscopic) video signals in a standardized format. In contrast to 3D-Ready TVs, 3D-Capable TVs integrate decoders that reconstruct the stereo signal from the compressed stream and must be compliant in terms of receiving capabilities to the respective services. The most likely services to be supported by these classes of devices would be based on cable delivery, terrestrial broadcast or Internet-based services. In the case of cable and terrestrial, current generation TVs are already supporting 2D services, so the extension of services to 3D would be the main focus. In doing so, it is not expected that changes to the RF front-end, tuner or demodulation would be needed. However, depending on the compression format, there would be changes required to the decoder and display processing sections.

It is expected that 3D services would utilize advanced codecs such as MPEG-4/H.264 AVC [2]. Two candidate formats are considered in this paper, including full-resolution stereo and frame-compatible formats.

The advantage of frame-compatible formats is that existing 2D decoders could be utilized. Depending on the frame packing arrangement, the reconstructed frame would then undergo conversion to the native display format. This is similar to the conversion discussed earlier in the context of 3D-Ready TVs, but rather than relying on external conversion, the conversion would be an integral part of the display processor. Since the reconstructed image format would be specified by the service, the number of conversion possibilities would be limited and pre-defined. While the adoption of frame-compatible formats would enable faster deployment of 3D services, resolution of the video is compromised prior to delivery and further degradation may occur in the conversion process to prepare the stereo signal for display.

An alternative to the frame-compatible format is full-resolution stereo, e.g., as coded by a standard such as MVC. In this case, the decoder would need to be upgraded to support the selected compression format, and conversion from the full-resolution stereo to the native display format would be performed in the display processor. A conversion from full-resolution stereo to the native display format will generally ensure the highest quality, especially compared to the frame-compatible formats which may potentially go through two conversions (re-sampling) processes prior to display.

To support 3D content delivery through non-real-time (NRT) services, the system would additionally require storage and copy protection of the content. Similar requirements would also apply for delivery models that download 3D content from Internet servers for time-shifted playback.

The above issues are being considered by standards development organizations that specify the delivery formats for respective services, e.g., SCTE for cable [3] and ATSC for terrestrial broadcast in the US. The decisions made by these organizations will directly impact the design and level of support for 3D content in future 3D-Capable TVs.

V. CONCLUDING REMARKS

As 3D services are introduced, the TV architecture will continually evolve. Standards are needed to ensure interoperability at various points in the delivery chain. While new devices should be upgraded to support these new standards, utilizing legacy devices must also be accounted for.

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