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High Density Audio Transcoding for Broadcast Applications

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Abstract

The demand for high density multimedia transcoding has skyrocketed due to variety in multimedia compression formats being followed in the industry, myriad delivery techniques and disparate requirements of target devices. Multimedia transcoding is no longer just a conversion to compatible standard. Due to the vast array of devices, especially in the mobile broadcast segment, the same content is being transcoded to multiple formats, bit-rates and resolutions. The Digital Broadcast industry itself is in an evolving stage with no particular technology having a clear dominance and universal acceptance. Choosing the right transcoding solution and catering to multiple target devices has become a key to success in the broadcast market.

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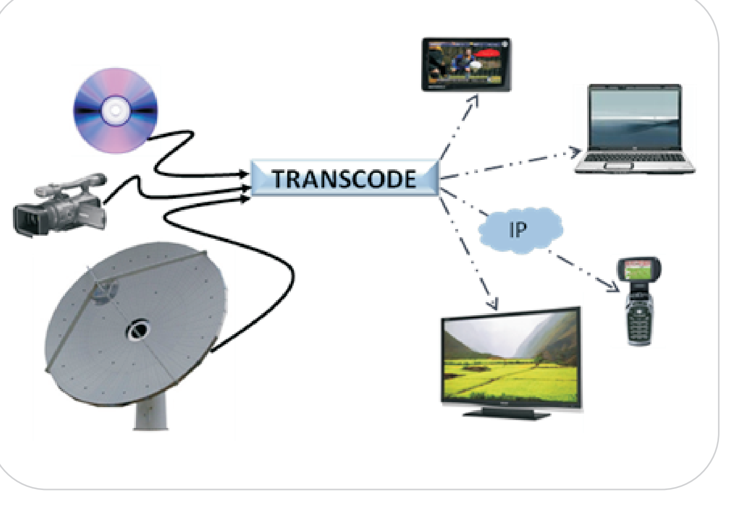

Designing a dense and scalable multimedia transcoding solution, which caters to these fluid requirements, has become challenging. This whitepaper tries to unravel few aspects of designing a multimedia transcoding system with emphasis on Audio transcoding. It examines the need for audio transcoding and the audio compression standards involved. Various design options and key requirements for designing such a dense and scalable transcoding system, are discussed. An audio transcoder sub-system, which could ease transcoder system development and integration, is presented. An analysis of TI DSPs suitable for such high density audio transcode solutions is provided.

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Digital Broadcast

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Need for Audio Transcode

	Dolby AC-3®	MPEG HE-AAC	MPEG Surround	MPEG Layer 2	Mp3	Microsoft WMA®	FLAC
Production and DVD	•			•			
Archival	•			•			•
Fixed TV Broadcast	•			•			
Mobile TV Broadcast		•	•				
Internet Streaming		•	•		•	•	
VOD through IP	•	•		•	•		
IPTV	•	•		•	•		
Television sets	•			•			

Table : Audio Compression formats used across broadcast industry

Today there exist multiple formats in which multimedia content is contributed, archived, distributed and broadcast. The table below lists the various audio compression formats used in the multimedia broadcast and streaming applications.

The multi-media compression formats being used for archival and distribution, like DVDs etc, has not changed from the legacy technologies. However, broadcasters are adopting newer compression schemes which provide significant bandwidth savings over legacy compression techniques. The receivers have evolved from being 'Fixed' in home to being 'Mobile' in moving vehicles, cell-phones and handheld devices. The requirements for transmissions to a mobile receiver are different from that of a fixed receiver. The various transmission schemes like satellite, cable, terrestrial for fixed and mobile receivers provide different per-channel bandwidth. This has resulted in the same multimedia content being delivered in different formats to different end-equipments. Different regions in the world have adopted differing technologies for Digital television transmission. This necessitates a broadcaster to transmit the same multimedia content in multiple formats, with different bit rates and resolutions in order to cater to all the needs of the broadcast market.

> Broadcasters are adopting newer compression schemes which provide significant bandwidth savings over legacy compression

Audio Transcoding Market

Traditionally digital broadcasts have been targeted at fixed television sets through terrestrial and satellite transmission techniques. MPEG 1 Layer 2 and ATSC A/52 have been the audio technologies used for such broadcast. These compression technologies also happen to be supported by DVD and Blue-Ray Disk standard, which are a source to a lot of content for broadcast. Audio content contribution for broadcast in terms of news and other live content has also, traditionally, been done using these formats. The bandwidth constraints for the fixed TV transmissions are low and the traditional audio codecs suffice.

Efficient codecs like MPEG Surround, HE-AAC Stereo and HE-AAC Multi channel are more suited to bandwidth hungry Mobile & Handheld digital television broadcasts.

Research and development in Audio compression algorithms have resulted in codecs like HE-AAC and MPEG Surround which provide excellent quality for Stereo and multi-channel audio even at low bitrates. These new codecs provide a 3x to 5x saving in the transmission bandwidth for multichannel audio compared to legacy codecs. Introduction of Mobile TV and IPTV technologies have given a new shape to the multimedia broadcast industry, bringing in new challenges. These new and evolving technologies demand content in varied forms based on the capability of the target device. Mobile TV transmissions are typically done at lower bitrates in the range of 300 kbps to 1 Mbps. Most of the available bandwidth is required for an acceptable quality video transmission which demands a high efficiency audio compression scheme for quality sound reception at the mobile receiver. This is where efficient codecs like HE-AAC Stereo, multi-channel and MPEG Surround come in.

The next sections of the paper discuss the requirements of a transcoder system suitable for broadcast applications, transcode system architecture and Audio transcoding challenges.

Design Requirements

A typical broadcast gateway handles about 100 to 200 channels. Multiple transcoder units are normally employed which can together serve this demand. Hence, total space occupied by a single transcode unit and the transcoding density offered plays an important role in selecting a particular solution.

Channel density

To conserve power and space, it becomes desirable to employ minimal units to transcode the media streams of all these channels. The total number of media streams to be transcoded might be higher if the broadcast unit serves both fixed-TV and mobile-TV broadcast. Hence the maximum channel density that can be achieved on a single transcoder unit becomes an important factor.

Diverse codec combinations

The input streams to the broadcast station might be originating from diverse sources and being transmitted to a vast array of target devices. Hence the transcoder system should be able to support multiple codec combinations for transcode.

> Channel density, power consump-tion, transcoding delay and support for diverse codec combinations are the key requirements of a high-density transcode solution

High Input/output throughput

A single program within a transport stream would consume 15 Mbps to 20 Mbps bandwidth. To service multiple such programs the system should have very high speed serial I/O or Ethernet interface which could support these throughputs.

Power dissipation

In most cases, a single DSP core would be insufficient to handle the high channel density necessary for the transcoder system. Multiple DSP systems would be employed to build a single transcoding rack unit. The total tolerable power dissipation for the rack unit limits the total number of DSPs that could be used within a single unit. A DSP with a low power rating would be preferred to get an optimal power rating.

Transcoding Delay

The transcoder systems inherently introduce delay due to factors like input-buffering, RTP/MPEG-TS parse/mux delay, algorithmic delay in the codecs and various other buffering delays. Minimizing the total end-to-end delay that a stream encounters due to transcoding is an important factor.

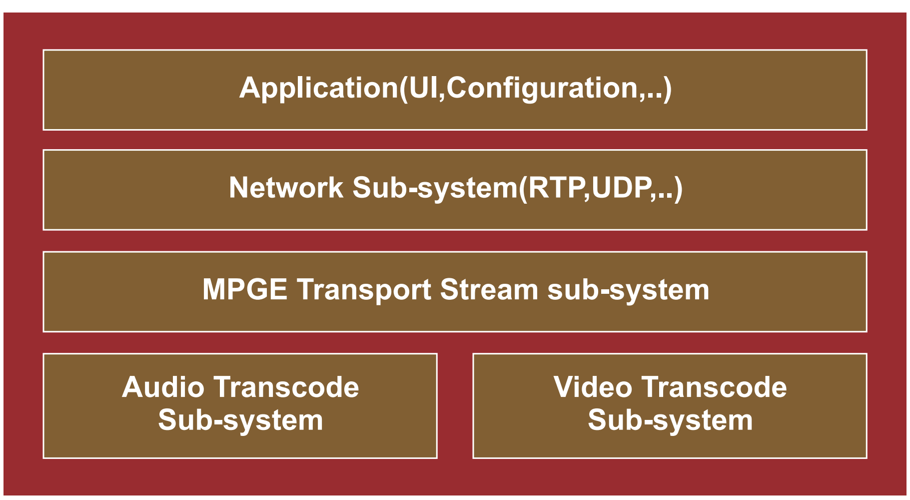

Figure 1 : Transcoder System Architecture

Transcoder System Architecture

The figure shows the system architecture of a multimedia transcoder used in a mobileTV, IPTV broadcast or the traditional satellite and terrestrial broadcast system. These transcode systems are connected to other broadcast end equipment using high speed interfaces like DVB/ASI(Asynchronous Serial Interface), SDI(Serial Digital Interface)), and Gigabit Ethernet for data transmission. The data is typically encapsulated with the MPEG2-TS to efficiently handle multiple programs. This may be further encapsulated with network protocols like UDP, RTP etc for transmission over IP network. To support both transport stream and IP encapsulation, the network protocol stack and MPEG2-TS Mux/Demux components are inherent blocks of such transcode systems.

- Support handling of DVB, ATSC, DMB transport streams and provide mux and de-mux functionality.
- Support transport streams with single program containing multiple elementary streams as well as multi-program streams.
- Seamlessly handle transport streams with changing compression formats, splice points, change in programs/stream attributes etc,.
- Support bypass of non multimedia data like tele-text, subtitle, closed captioning etc., present in the transport stream.
- Support bypass of elementary streams, requiring no transcoding, with minimal overhead.
- Support transmission and reception over UDP/IP Ethernet links.
- Support RTP/RTCP protocols for control over transmission error.
- Effectively handle the network jitters associated with Ethernet transmission.

Key Features

- TS handling and Network functionalities are necessary for building complete transcoder systems.
- Components should support varied design options chosen based on the channel density demands.
- The transcoder system should be able to interface with different broadcast systems

Audio Transcode Sub-system

Audio transcoding solutions would typically need to modify the channel configuration (E.g. 5.1 to Stereo) and the sampling rate (E.g. 48 kHz to 44.1 kHz) apart from changing the encoding format of the audio stream. The sub-system should be designed such that it maps the configuration from the decoded stream to the encoder and at the same time provides for Down-mixing and Sample-Rate conversion. The design should take care of any side information or metadata present in the decoded bit-stream to be mapped to equivalent parameters in the encoder to maintain the listening experience after transmission. The sub-system should also be able to measure and provide the algorithmic delay encountered by the stream while being transcoded to maintain the overall audio-video synchronization.

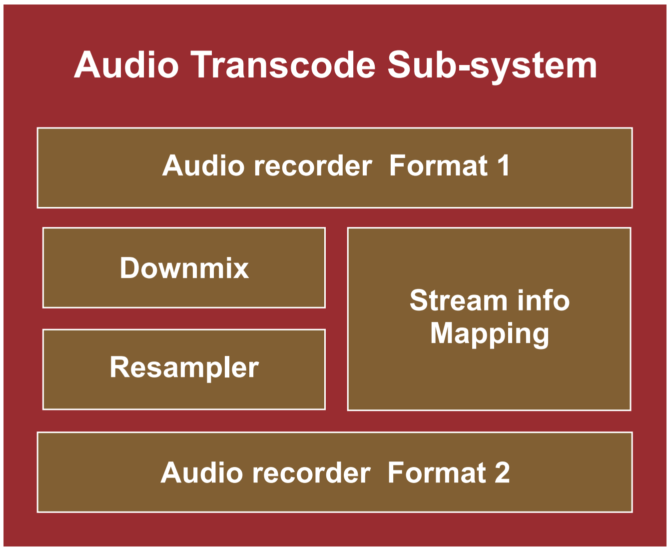

Figure 2: Audio Transcode sub-system

Key Features

- Should support various audio codecs needed by different broadcast standards.
- Should support selecting the audio decoder and encoder pair while transcoding.
- Should support configuration mappings from the input bit-stream to the transcoded stream.
- Should support modifying the number of Channels and Sample-Rate of transcoded stream.
- Should support configuring the encoder parameters like bit-rate, tools, etc.
- Should be capable of providing accurate algorithmic transcoding delays to compensate for the play out time-stamps of transcoded stream.

- Should support multiple decoders and encoders needed by different broadcast standards.
- Should support selecting the decode-encode pairs and configuring the encode parameters.
- Should be scalable to add in more decode-encode pairs.
- Should compensate transcoding algorithmic delay.

Transcoder System Design options

There are multiple choices for designing a transcoder system. The choices revolve around the following points

- Microcontrollers are typically more efficient at handling I/O, running Network Stacks and running MPEG2-TS Mux/De-Mux. They are also efficient in running an OS and application for configuring the underlying transcoder system.
- DSPs have the raw horse-power and can provide higher channel density. A high channel density can be achieved for Audio Transcoding on such DSPs.
- The Video Transcoding could be done either on a DSP or on an ASIC which can provide real-time SD and HD Transcode.

Case 1: Heterogonous Design

This assumes that the control intensive processing like transport stream handling and network stack operations are done on a microcontroller and the core Audio and Video transcoding is done on a DSP. The microcontrollers are typically more efficient at handling control intensive operations which facilitates developing rich applications for web interfaces and user interface. Here the data transfer speed between microcontroller and DSP would be the governing factor in deciding the maximum channel density. The Video transcoding could be shifted on to an ASIC, in which case, the microcontroller performs the audio video data arbitration to feed-in and collect transcoded data from DSP and ASIC.

Case 2: Homogenous Design

This assumes that the entire application, N/W stack, MPEG2-TS and transcode is implemented on the DSP. The application could have a minimalist control and configuration functions. Such a design also provides scalability in terms of channel density since additional DSP cores could be added to the system. The Video Transcoding could be done on the same DSP or on an additional ASIC. In case an ASIC is used, the maximum I/O data-rate that the DSP can handle and the max-speed of data transfer between the DSP and the ASIC, determine the maximum channel density.

TI-DSPs for Transcoding solution

Texas Instruments has a set of DSPs especially made for power hungry multi-core DSP designs. A few of these TI DSP's have been analyzed for suitability for Audio transcode application and are discussed in this section. The various considerations and options to design a transcoder system have been discussed previously. The subsequent sections describe the factors to be considered while choosing the TI DSPs.

Factors for choosing a TI DSP

- Required channel density, i.e. the number of simultaneous audio streams needed to be transcoded by a single transcoder unit. This would determine the total horse-power MCPS demanded from the DSP.
- Availability of high speed serial I/O interfaces. The interfaces and the I/O bandwidth available play a major role in selecting a particular DSP.
- Memory interfaces provided by the DSP and the DDR speed. This would be necessary when the DSP is interfaced with an external ASIC.
- Cache sizes and the memory read/write delays. This would have a direct impact on the channel density.
- The amount of system tasks i.e. RTP send/receive, TS Mux/De-Mux, Output Audio-Video synchronization etc. to be handled by the processor. This would determine if a DSP alone processor is sufficient or a microcontroller+DSP is necessary
- The presence of efficient DMA transfer hardware to compensate for low speed external memory.
- Overall power rating of the DSP. This would determine the number of DSP processors that could be assembled in a single rack unit.
- Cost of the DSP.
- Availability of audio codecs and system components on a particular TI DSP

The Table below lists the features available on a set of TI DSP processors suitable for audio transcoding applications

Processor/Features	C6455	C6474	C6424
Description	1 C64x+ Core	3 C64x+ Cores	1 C64x+ Core
Max CPU Mhz	1200 MHz	3 x 1000 MHz	700 Mhz
Memory - L1	32 KB I,32 KB D	3 x (32 KB I,32 KB D)	32 KB I,80 KB D
Memory - L2	2048 KB	3 x 1024 KB	128 KB
I/O - Ethernet	Gigabit	Gigabit	10/100
SRIO	4 1x Links	2 1x Links	No
EMIF	32 bit DDR2	32 bit DDR2	32 bit DDR2
DMA	64 Ch EDMA	64 Ch EDMA	64 Ch EDMA
DDR2 Speed	533 MHz	667 MHz	333 Mhz
Power	3 W	6 W	1 W

Table 2: TI DSP Feature comparison

MHz per Watt	400	500	700

Note the following about the information in the above table -

- The processor features essential for audio transcoder application development have been highlighted and compared.
- The Max CPU Mhz is the performance of the highest variant of the DSP available.
- It is advisable to refer to the TI website to get accurate and comprehensive information about these and other processors.

Conclusion

In the broadcast industry transcoding has become a necessity to serve a wide range of target devices. As must be clear to the reader, there is a multitude of factors that govern the dynamics of platform selection for the transcode system. Apart from raw DSP horse-power, the power dissipation and space requirements also play a significant role in designing the system. With emerging of new technologies and standards within the broadcast industry, scalability of a design to support additional codecs is a necessity. Packaging of codecs, pre-testing all possible configurations mapping between the decoder and encoder and pre-testing transcoded audio quality eases system integration, saves time and ensures optimum listening experience.

Reference

- **EBU TECH 3324** EBU Evaluations of Multichannel Audio Codecs
- **TI Datasheets** for DM648, C6455 and C6474.
- **ETSI TS 101 154** DVB; Specification for the use of Audio and Video Coding in Broadcasting Application based on MPEG-2 Transport Stream
- Texas Instruments C6474 **Press Release**

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