Project Name:
Multi-Stream Video Coding for Hybrid UHD Television Services over Internet Protocol

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Abstract

1 Abstract

Commercial TV broadcasts usually utilized expensive licensed frequency spectrum with limited bandwidth and also heavy regulated by the government. This prevent broadcaster from moving to 4K UHD broadcast. While moving to online TV is one of the options, people with slow or no internet will not able to watch anything. Another solution to tackle these problems is Multi-Stream Video Coding. This project aims to transmit 4K UHD video stream by using the terrestrial TV broadcast to reduce internet bandwidth requirement while maintaining reasonable image quality.

4K UHD video source will be encoded using the traditional method for terrestrial broadcasting, then it will be deinterlaced and upscaled to 4K UHD. The differences between interpolated stream and the actual 4K UHD source will be taken and this information will be encoded as another video stream, which can be sent through the internet.

The receiver with appropriate capability will take in both terrestrial broadcast from antenna and delta stream from the internet and assemble 4K UHD video stream based on these two streams. Moreover, backward compatibility is maintained as the terrestrial broadcast hasn't been modify from the standard regulated by governments.

2 Introduction

Due to the new fabrication process in TV panel production, the price of larger television is getting much cheaper to the point that most consumer can purchase. The new panel also comes with much higher resolution than ever before. Large panel size and increased resolution both allows the consumer to spot any imperfection in the content that is being played more noticeably. However, most commercial TV broadcast is still in 1080i, which is sixteen times lower resolution than what 8K TV has to offer. This is because these broadcasts utilized expensive licensed frequency spectrum to deliver the content, whereas streaming services like Netflix and YouTube takes advantage of the internet to deliver content up to 8K with much lower cost. Broadcasting on licensed frequency spectrum has many advantages such as high reliability, no interference, and no bandwidth sharing, but radio frequency is limited resource and when every broadcaster wants to switch to 4K transmission, more bandwidth is required, and when everyone wants more bandwidth, the price of the license will be skyrocketed.

The alternative solution is to do terrestrial/satellite broadcasting in old 1080i standard and stream 4K feed through the internet. However, not everyone has an access to fast internet. According to NBTC, 50.1 million people out of 69.4 million people in Thailand has an access to the internet. That still leave a significant amount of population of about 20 million people without internet and even though the rest has the access to the internet, only small percentage of people has a fast-enough connection to stream 4K video, which demands around 20-30 Mbit/s. This will potentially limit the number of people who will have the access to 4K stream.

As you can see, each delivery method has its strengths and weaknesses. Combining multiple method will reduce some of the weaknesses each method has "memory". The memory can hold the past events in itself and change the output accordingly.

3 Project Idea

By utilizing the bandwidth of both terrestrial/satellite broadcasting and internet, 4K stream can be delivered with less internet bandwidth requirement and potentially accessible by more people. But if the data packet of 4K video is being split evenly across terrestrial broadcast frequency and internet, not only government's regulation that stated that the frequency can only be used to transmit 1080i digital television service is violated, but people without internet at all won't be able to watch anything. Therefore, it's better to encode 4K UHD source into two video streams: base 1080i stream, which is normal digital television service as regulated by government, and delta stream, which contain only the difference between 1080i stream and 4K UHD source. By using an appropriate upscaling and deinterlacing algorithm, the difference between 1080i and 4K stream can be reduced to save more internet bandwidth.

By utilizing this method, even people with basic internet service can enjoy 4K UHD content. Additionally, this method also guarantees that even in the worst-case scenario such as connection being cut-off or reduced speed due to network congestion, 1080i video stream will be delivered to the audience. Therefore, it takes advantage of licensed frequency spectrum's high reliability and the low cost of the internet.

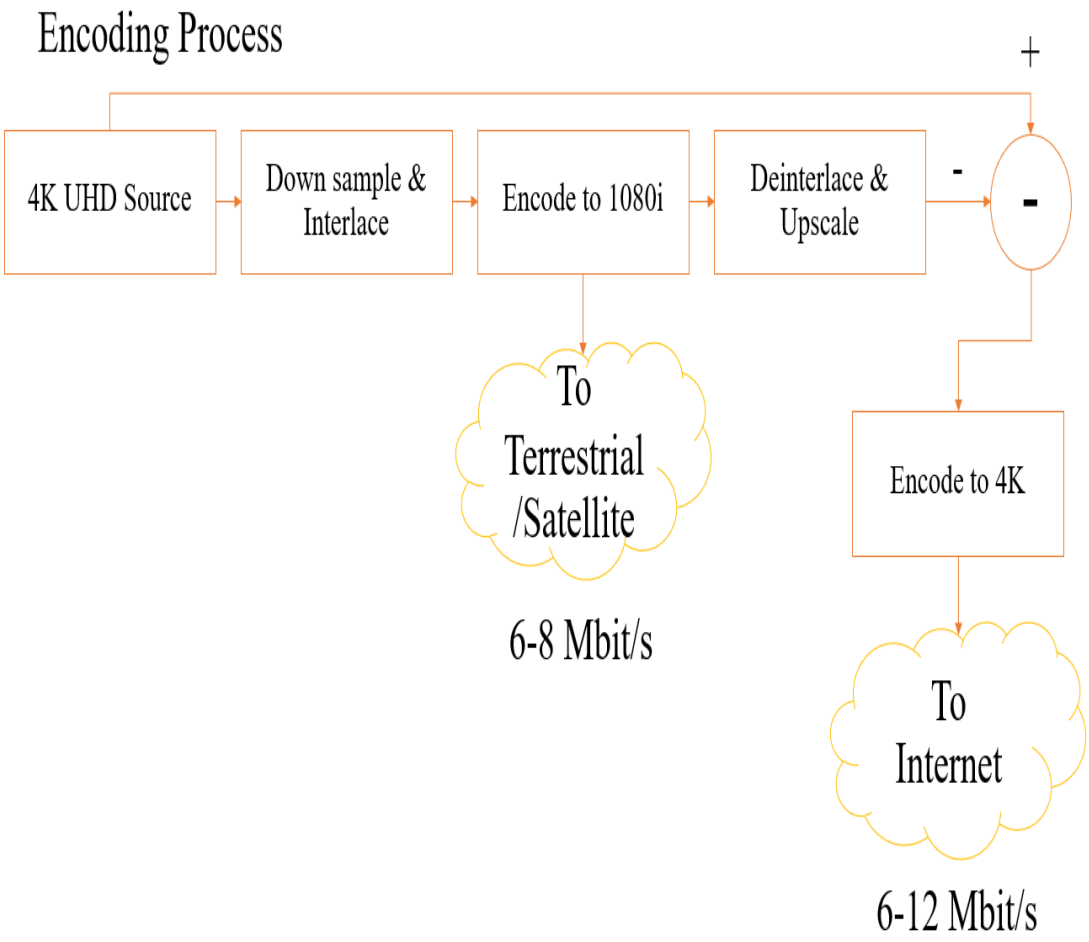

Figure 1: Endcoding Process.

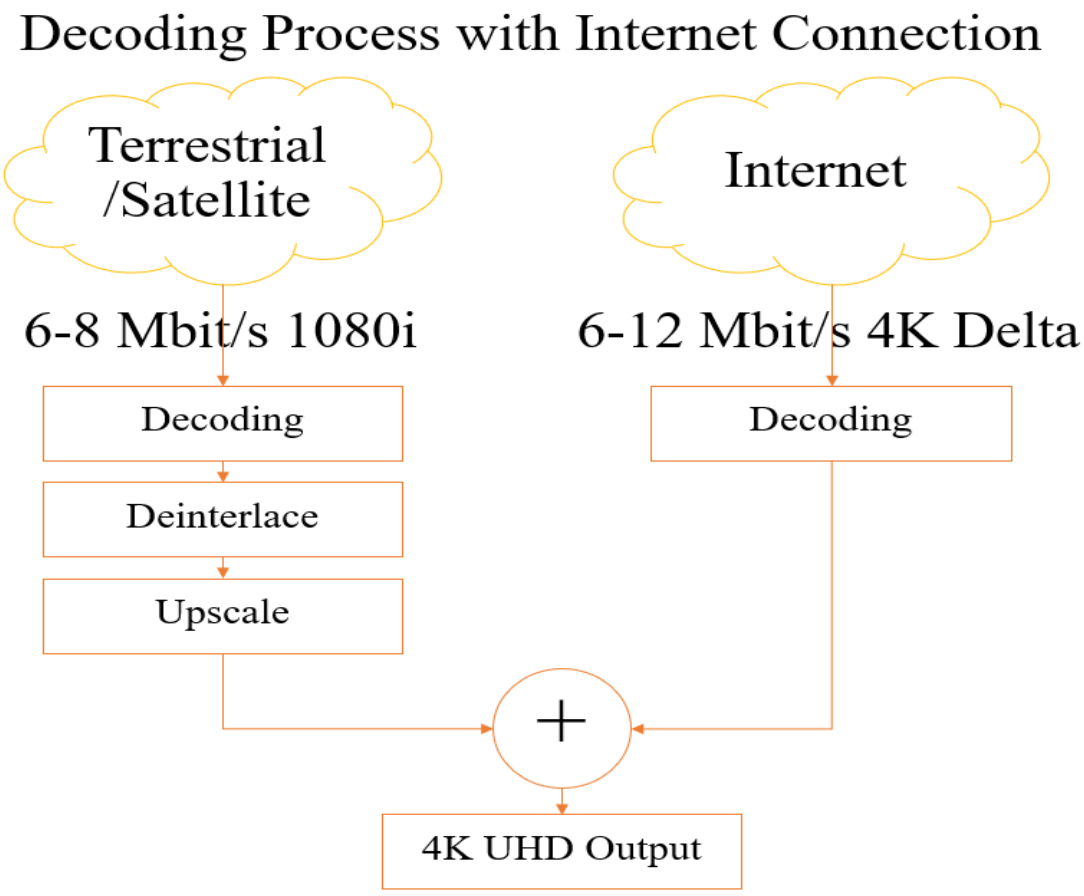

Figure 2: Decoding Process.

4 Objective

- Utilizing 1080i stream to deliver better quality 4K UHD stream at the same internet bandwidth requirement.

- Optimizing deinterlace, upscaling, and encoding process to find out suitable algorithm that yield the best image quality at given data rate limit.

- Open opportunity for TV stations to deliver 4K UHD content to people who has limited internet connections.

5 Overview

5.1 Initial Study Background Study

5.1.1 Limitations of Traditional Commercial TV Broadcast

Since the early 21th century, many countries around the world start to adapt digital television. Old analog television utilizes channel bandwidth between 6-8 MHz per channel depending on television standard that each country adapted. By utilizing digital compression, several HD channels containing 1080 lines, compared to 525 or 625 lines of NTSC and PAL system, respectively, can be transmitted using the same amount of bandwidth. Additionally, digital television also enables higher quality audio and multi-language closed captioning compared to single language teletext in analog system.

Even though, digital television saved a lot of bandwidth compared to analog system and offers additional services that wasn't available in analog television system, an improvement in TV panel fabrication process plays a huge role of reducing the price of large TV screens. This results in widespread of 4K UHD Television in consumer market drives the demand for 4K UHD contents.

5.1.2 Codec Limitation

Although, online streaming platform like YouTube or Netflix can update to utilize newer codec for better image quality at the same data rate and even increase data rate or resolution as desire, commercial broadcaster must follows many standards, which put many constraint on codec, data rate, frame rate, and resolution that broadcasters may use. These standards are rarely update, which force broadcasters to use old technology at the time that the standard specification was published. In Japan, ISDB-T standard is being used since December 2003 and the specification force broadcasters to use MPEG-2 codec from 1995 even newer and more efficient codec such as MPEG-4/AVC and MPEG-H/HEVC are being used widely in online streaming industry.

5.1.3 Data rate Limitation

Due to limited amount of frequency spectrum are available for television broadcast, some country may choose to cut down video data rate, which not only cripple the image quality of 1080i HDTV broadcast, but also eliminate possibility of delivering 4K even with more efficient codecs. The table below shows resolutions, codec and data rate combinations used in some country around the world compared to commercially available 4K UHD channels.

Even though, some country may have enough data rate available for the upgrade to 4K UHD, but that will eliminate any possibility of backward compatibility and require everyone to purchase the new receiver to continue receive the service.

5.1.4 Interlaced Video

Additionally, most HDTV standards enforce the broadcasters to choose the resolution between 720p and 1080i. 720p offers lower resolution, but offers full 50 or 59.94 frames per second in PAL and NTSC country, respectively. However, 1080i offers higher resolution, but only offers 50 or 59.94 fields per second depending on the country. Instead of containing full image like frame, field contains only half of the lines at a time, so the old and even lines of the image are being updates alternatively every other field. Unlike analog TV, which the glass tube is designed for scanning every other line each refresh cycle to display interlace signal, modern television set contain LCD panel, which is being scanned progressively. This updates every line at every update cycle, so the process called deinterlace must be done to convert interlace signal to progressive frame before being sent to the panel. This process could be done differently depending on algorithm implemented in each TV set. Usually, lower end sets will just simply be combining two fields into one frame, which reduce temporal resolution to 25 or 29.97 frames per second. Higher end television with more processing power usually interpolate the missing lines to gives out 50 or 59.94 frames per second. While this work for slow paced contents like news or animations, it tends to fall apart when it comes to high motion contents such as sports and concerts leading to deinterlace artifacts. This might not

be noticeable on smaller screen, but as larger TV panel becomes cheaper, it's easy for the audience to spot such artifact. On the other hand, online streaming platform like YouTube and Twitch allow broadcasters to stream in full 1080p at 50 or 59.94 frames per second, which totally eliminate the problem of interlaced video.

5.2 Technical Challenges /Issues

This project focusing on maintain optimum picture/video quality while reducing the need for inappropriate internet bandwidth to stream 4K UHD video using terrestrial TV broadcasts. However, there are some obstacle such a data rate limited. In telecommunications and computing, bit rate is the number of bits that are conveyed or processed per unit of time. it is a very important consideration in data communications as it can judge how fast we can transmit data, in bits per second, through a channel.

5.2.1 How does bitrate affect video quality?

Broadcasting is undoubtedly a powerful way to connect with viewers. But what's the key to creating a high quality looking live video? Some might say it's the gear you use, but what is more important, it is the bitrate that the video is recorded as this directly affects the size of the file and the quality of the video you will get when streaming.

5.2.2 Bitrate and bandwidth limits

When broadcasting, you may encounter bandwidth limits for transfers, uploads, and downloads. Bandwidth determines the maximum network throughput required to upload and download data. As a result, it transfers data between broadcasting and audiences. Therefore, the larger the data request, the higher the bandwidth must be sent. When the bandwidth is insufficient it will cause breakpoints and slow down the transfer process.

For some case, there are limited amount of frequency spectrum are available for television broadcast in Thailand.
According to, CAT Telecom Public Company Limited, consult No. 40/2013 on Monday, November 4, 2013, it was suggested to approve the options of the GSK sublease agreement, which presumed to have 4 as the table below.

Option	Number of HD channel	Number of SD channel
1	0	12
2	1	9
3	2	6
4	3	3

Table 1: Technical Guidelines for Digital Terrestrial Television Broadcasting 2017.*Office of Broadcasting and Television Engineering and Technology (NBTC), Office of NBTC, pp. 15.*

By setting the minimum and maximum bitrate of the video signal for all options, make multiplexing allocation more efficient. It was found that a statistical multiplexer was required in combination with an encoder device that was comparable in performance to the third generation (Third Generation Encoder).

Signal rate (Mbps)		
-	Minimum	Maximum
SD	0.75	2.5
HD	2	7

Table 2: Technical Guidelines for Digital Terrestrial Television Broadcasting 2017.*Office of Broadcasting and Television Engineering and Technology (NBTC), Office of NBTC, pp. 15.*

DVB-T2 Parameters: 16k ext., GI 19/128, PP2, 64-QAM, CR 3/5, L1Post:BPSK Time Interleave Depth = 87.58 ms.	Total Bit Rate 21.86 Mbps			
ITEMS	Option 1	Option 2	Option 3	Option 4
Number of HD Channels	0	1	2	3
Number of SD Channels	12	9	6	3
TOTAL CHANNELS	12	10	8	6
BIT RATE	(kbps)			
Video Bit Rate (Pool Bit Rate with Statistical Multiplexing) - SD Bit Rate (min-max) = 0.75-2.5 Mbps - HD Bit Rate (min-max) = 2-7 Mbps	18400	18700	19000	19000
Audio Bit Rate (70 kbps per one stereo, 2 tracks per channel)	1680	1400	1120	840
Audio Description (35 kbps per one stereo, 1 track per channel)	420	350	280	210
Subtitles (100 kbps per channel)	1200	1000	800	600
SI (EIT) or EPG	300 *	300 *	300 *	300 *
SI (PMT) (25.75 kbps per channel)	309	257.5	206	154.5
SI (others) = 64 kbps	64	64	64	64
TOTAL PAYLOAD	22073 **	21771.5 ***	21470 ***	20868.5 ***
Reserved for SSU and others	-213 **	88.5 ***	390 ***	991.5 ***

Figure 3: Table3: Technical Guidelines for Digital Terrestrial Television Broadcasting 2017.*Office of Broadcasting and Television Engineering and Technology (NBTC), Office of NBTC, pp. 16.*

In the event that the bit rate is not used, the network capacity is not full, or the number of channels is less than the specified option, the rate may be adjusted. Video Bitrate Pool bits as appropriate for each network. It provides the lowest and highest bitrate of the video signal for each channel. It is according to the original specification. So, the maximum data rate that each MUX would be sent is approximately 21 Mbps and even less for each channel.

5.2.3 How to deal with bandwidth limits?

By utilizing the bandwidth of both terrestrial / satellite broadcasting and internet, 4K streams can be delivered with less internet bandwidth requirements. . . . . .

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