# Content Repurposing for Mobile TV Networks

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## Abstract

Today a few content only exist for Mobile TV broadcast and there is a strong need in adapting existing contents from different formats to fit in handsets' small screens. Present conference highlights major technical challenges to provide the highest possible quality while transcoding content from SD to Mobile TV video format. Different video coding formats will be introduced according to the target Mobile TV networks, presenting as well the main constraints brought by watching TV programs on a Mobile phone. Dedicated techniques and algorithms have to be used to take the most out of the Mobile TV transcoding chain, and a set of solutions to optimize transcoding processing for a smooth integration in a Mobile TV system will be listed.

This paper is organized as follows:

- 1- The source: existing TV networks
- 2- The target: Mobile TV
- 3- The processing: How to repurpose?

## *1The source: existing TV networks*

When we talk about repurposing, we first need to have a deep look at the source. Where does the content come from? Mainly from satellite, from cable or from terrestrial networks.

TV programs on-air today are in digital format. Even on terrestrial networks, despite many countries around the world currently operate terrestrial services in both analog and digital for historical reasons, all the analog services will be switched off in the coming years, always replaced by digital TV.

### .1.1Digital TV

Digital TV has been introduced in late 1990s and progressively replaced previous TV broadcast systems based on analog systems to transmit TV. Digital TV brings more efficiency, more flexibility and also provides better quality for TV delivery.

Digital TV technologies provide ways to transmit and transport TV signal in a digital way. The company consortium called the DVB project (DVB: Digital Video Broadcasting) defined and published a set of open standards that where internationally accepted as the de-facto digital TV standards. In this set of standards, all the aspects have been defined to ensure interoperability of digital TV around the world. Some major elements of these standards are based on works from MPEG (Moving Picture Experts Group), famous working group of

ISO/IEC organizations.

Like DVB, ATSC (Advanced Television Systems Committee) published digital TV standards used in the United States and some other countries.

## .1.2Coding standards

Compression - or encoding - has always been a requirement to digitally transport video and audio data.

MPEG especially developed video and audio encoding standards. For broadcast-quality television, MPEG video compression has been used in all the existing digital television systems. The first MPEG project defined in 1993 was MPEG-1 (ISO/IEC 11172) and was mainly targeted for VideoCD compression. MPEG-2 (ISO/IEC 13818) standard, published in 1995, is capable of coding standard-definition television at bit rates from about 3-15 Mbit/s and high-definition television at 15-30 Mbit/s. MPEG-2 also extends the stereo audio capabilities of MPEG-1 to multi-channel surround sound coding.

In short, the goal of compression algorithms is simple: reduce bit rate to carry the video data while preserving the quality. The bit rate reduction is obtained to take advantage of 2 kinds of redundancy present in video signals:

- Temporal and spatial redundancy: Image pixels are not independent: pixels are correlated with their neighbors both within the same frame (spatial redundancy) and across frames (temporal redundancy) . To some extent values of neighboring (in time or in space) pixels help to predict other pixel values.

- Psycho-visual redundancy: Thanks to human eyes that has limited sensitivity to some details (object edges, ...), it is possible to introduce impairments (artifacts) in a compression/ decompression chain without troubling the quality perception of human eyes.

## .1.3Video formats

Digital TV transition has first been forced to keep many of traditional analog TV constraints to avoid replacing all the TV receivers when switching from analog to digital broadcast. For the video format, the Standard Definition (SD) has been used when broadcasting at the same resolution as analog systems. For the color encoding systems, it means that the two main formats used worldwide in analog TV continued to exist in the digital world: NTSC and PAL.

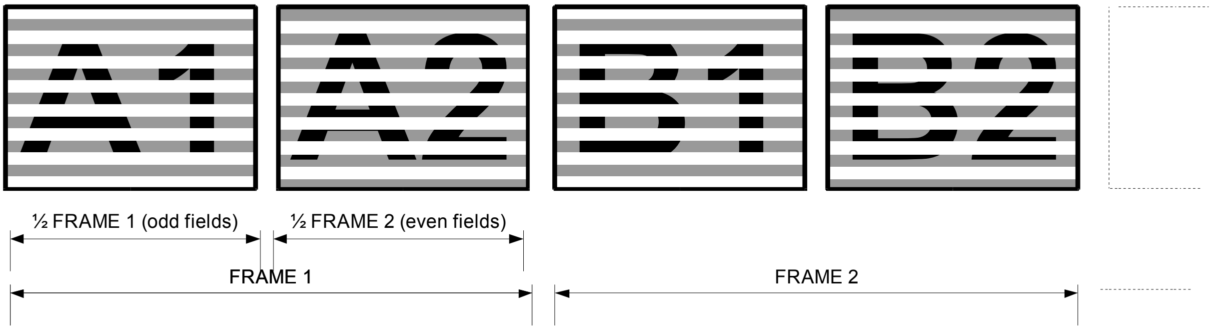
This is a concern when we talk about repurposing the content because the two color systems differ in vertical resolution and in temporal resolution. The vertical resolution is measured in number of lines that composes the image. The temporal resolution is measure in frames per seconds, or more exactly in fields per seconds. We will go through this fields/frames aspect in a section later about interlacing video.

NTSC, used in North America, Central America, Japan and some other countries provides images composed of 525 lines at about 30 frames per seconds (with 486 visible lines, the rest being used for other information such as sync data and captioning). PAL, used in large parts of the world (Europe, Asia, Africa, ...) provides images composed of 625 line at 25 frames per seconds (576 visible lines). So for comparison, PAL uses has a higher vertical resolution, but a lower temporal resolution than NTSC. For the horizontal resolution, both uses 720 columns in digital format.

More recently, digital TV has been extended to offer bigger resolutions than analog systems commonly referred as High Definition and is composed of multiple formats (720p, 1080i, ...)

### .1.4Interlacing

Interlace is a method invented in the 1930s to improve the picture quality of a video signal by removing some flickering artifacts on cathode ray tube screens. It consists of painting alternatively half-resolution video image to take advantage of human eye persistence. Instead of painting every single frames at about 25-30 frames per seconds (called progressive scan), the images is refreshed at about 50-60 times per seconds but only half of the image (bottom and even lines alternatively).




Even if cathode ray tube are being replaced with progressive displays (computer screens, LCD TV, ...) all over the world, current digital TV signals - in single definition - is still in interlaced formats. It then required smart methods to "remove" the interlacing effects to display the images efficiently on new displays.

## *2The target: Mobile TV*

Mobile TV is our target. This is where we want to put our content. But what are the specific requirements of Mobile TV? It is first important to notice that there are multiple existing Mobile TV systems and there is not only one definition that could cover all the Mobile TV requirements. We will concentrate our definition to what is really important for our concerns.

### .2.1Size and resolution

If we think mobile, we first consider “moving around". So the receiver size to watch TV should nearly be able to fit in a pocket. A 19-inches TV screen does not fit for our definition of mobile TV! Most of the Mobile TV devices on the market are built with screens from approximately 2 to 5 inches. For mobile phones, a maximum of 3.5 inches is often observed. One of the biggest challenge of the repurposing is to preserve a smooth user experience in about 3 inches for contents produced for tens

New standards that have been established for Mobile TV means new underlying technologies for transporting and coding the contents. There is no or few mobile devices that currently provide equivalent pixel resolution as a classic TV receiver. Please observe below a simplified list of recently released mobile TV devices and handsets characteristics.

| Device | Technologies | Screen size (in inches) | Resolution (width x height in pixels) |
|---|---|---|---|
| Samsung P930 | DVB-H, UMTS | 2.2 | 320x240 (QVGA) |
| SAGEM My750C | DVB-H, GPRS | 2.2 | 320x240 (QVGA) |
| ZTE / Onda N7100 | DVB-H, UMTS | 2.2 | 320x240 (QVGA) |
| Nokia N77 | DVB-H, UMTS | 2.4 | 320x240 (QVGA) |
| Sony Ericsson W960i | DVB-H, UMTS | 2.6 | 320x240 (QVGA) |
| LG U990 | DVB-H, UMTS | 3 | 400x240 |
| Apple iPhone | WIFI, EDGE | 3.5 | 480x320 |
| Quantum QTM1000 | DVB-H | 4.3 | 480x272 |

The goal is to repurpose TV to these resolutions while preserving the best user experience.

### .2.2Coding standards

New mobile TV standards brought new compression technologies. MPEG formed with ITU-T Video Coding Experts Group (VCEG) in December 2001 the Joint Video Team (JVT) with the purpose to develop a new video coding standard that it is usually known as MPEG-4 AVC or H.264. The main objective was to achieve at least the double of the coding compression, for the same video quality, when compared to all the available video coding standards.

While the MPEG2 coding standard has been standardized mainly targeting the broadcasting market with bit rate of around 4 Mbps for standard definition video, H.264 coding standard is flexible and offers a number of compression tools in order to support a range of applications with very low as well as very high bit rate requirements. It is now observed that H.264 standard gives equivalent video quality at up to 50% of MPEG2 bit rates.

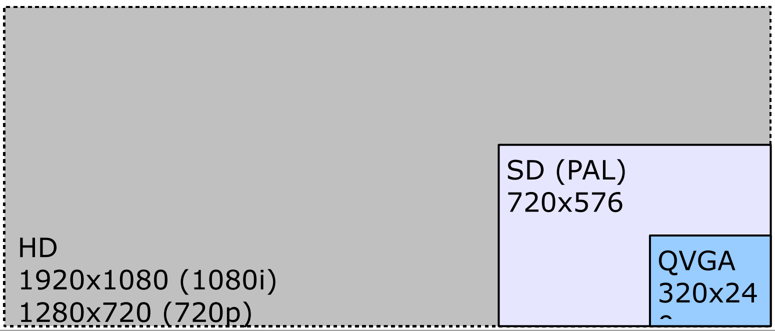
For comparison, typical bit rates used in mobile TV deployment are from 200 to 400 kbps.

## *3The processing: How to repurpose?*

So let's transform the content from the source – existing TV contents – to our target: mobile TV.

### .3.1Size and resolution

On one side, we have images with resolutions of 720x480 (NTSC) or 720x576 (PAL), or even sometimes larger (for High Definition). On the other side, we have Mobile TV handsets with



320x240 (QVGA), 352x288 (CIF) or even smaller resolutions. We quickly notice that we will need to rescale/resize the image to adapt to the new resolutions.

In image processing, tons of algorithms exist in this spatial resolution change domain. If you ever use any image manipulation software to perform some modifications to your personal pictures, you probably have already used one of this image scaling algorithm.

Several methods exist. Let's review three of them. The simplest method is called the "nearest neighbor interpolation", where the algorithm simply selects the value of the nearest point. This is a really fast algorithm but has really undesirable “stairway effects”. Another method to consider is called "bilinear interpolation". This is far better than "nearest" methods but the resulting image can still be jagged. A third method called "Bicubic interpolation" gives even better and sharper images. It requires however more processing power than "bilinear interpolation".

Which method should we use? It is always a trade-off of performance versus quality. If you want to get the best quality for the target video, always prefer methods that gives similar results as "bicubic interpolation".

## .3.2Coding standards

As we reviewed in previous sections, we need to move from MPEG-2 to MPEG-4. But this is of course far more complicated than just changing 1 letter.

MPEG-2 and MPEG-4 shares the same basic structure. More precisely MPEG-2 is a sub-set of MPEG-4. MPEG-4 brings major compression efficiency improvements over MPEG-2 but at the cost of a very higher encoding complexity. For many applications like real-time encoding, MPEG-4 requires large amount of processing power and any ways to simplify and reduce the encoding cost were studied. That was the first target of MPEG-2 to MPEG-4 transcoding: MPEG-4 encoding with minimal complexity. First methods that have been experimented was to only do the minimal changes in the MPEG-2 bitstreams to become valid MPEG-4 bitstreams. This requires to translate MPEG-2 coding tools into their MPEG-4 counterparts. This has the border effect to limit MPEG-4 tools to what was allowed in MPEG-2 and to not use any of the key improvements of MPEG-4 (better inter-picture prediction, new entropy coding systems, in-loop deblocking filter, ...). We then had a MPEG-4 valid streams but without the expected quality improvements.

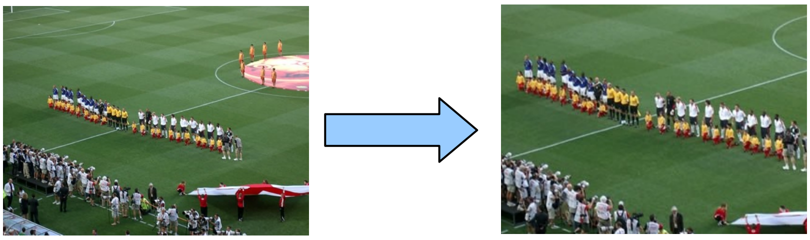
In SD to Mobile repurposing, as we intend to not only change the video coding standard but also to change the resolution and the bit rates, one pragmatic method is recommended: to combine a full MPEG-2 decoder and a full MPEG-4 encoder chained together. By doing this, more processing power is required but it allows to have an optimal MPEG-4 encoding for the target bit rate and also allows to do some image processing between the video coding standards.

## .3.3Framing

Anyone who has tried to watch a sport event, such as a soccer game, originally shot in for SD or HD television screen on a mobile screen can attest that the experience can be less than desirable:

- The ball can be invisible to track when the camera shows the complete game field,
- Players are often impossible to recognize,

- Scores and other on-screen informations are difficult or impossible to read.



This will stay a big concern until broadcast studios put in place dedicated camera or appropriate editing system targeted for mobile video.

The key solution to this problem is to isolate the best region of interest in every image and zoom to this region. The system must also preserve a smooth video experience and avoid too fast changing zooms over the time.

Thanks to some advanced image tracking solution, algorithms to identify regions of interest in an image have been applied to video sequences and provided some ways to automatically zoom to such region of interest. It is however unlikely that a complete automatic system will exist in the future. Every nature of content (sport, news, movies, ...) would imply really different mechanisms to isolate regions of interest and only human eyes and brain can really say "this part of the image is important".

## .3.4Temporal issues (Frames per second)

As mobile TV implies low bit rates, a trade-off is sometimes required between video smoothness and picture quality. It means that reducing the number of frames per second of a video at a given bit rate allows to allocate more bit rate for each frame. The result is that it gives a better quality for every frames. The side effect is that the resulting video will be less smooth.

Converting video from one given frame rate (25 or 30 fps – frames per second) to a lower frame rate could be done in different ways.

The basic solution is to simply drop the right number of frame to match the target frame rate. This solution is the simplest and best way if you transform to an exact fraction of the original frame rate. For example, when converting from 25 to 12.5 fps, dropping 1 out of 2 frames will give the appropriate results.

But if you convert to other values (from 25 to 20 for example), this solution will generate some smoothness artifacts that can be undesirable. A more advanced solution for this situation is to blend adjacent video frames, weighted by a blend factor proportional to the frames' relative timing. This solution could however cause visible, although slight, blurring of motion.

The best recommendation for this temporal issue problem is to keep the source frame rate whenever possible or to always convert to a fraction of the source frame rate.

## .3.5De-interlacing

As we analyzed in first section, most of existing digital TV contents are in traditional interlaced format. So when repurposing the content and transforming it, it is required to deal with this aspect. As we will never see a mobile handset with cathode ray tube, all the mobile TV standards are all in progressive video format (the opposite of interlaced).

Several methods (called de-interlacing) exist that recombine the 2 interlace fields into 1 frame. As the 2 fields have a slight time difference, it may result of “tearing” effects (alternate lines displaced from each other). Over the years, multiple algorithms have been imagined to avoid this effect. From the basic method that simply blends the 2 fields to advanced methods using motion compensation systems to better align the 2 fields, you will find many literature about de-interlacing methods everywhere.

We can do better: when rescaling SD images to resolutions with half or more of the original height, the simplest and most efficient aspect is to simply use 1 out of 2 fields in the vertical resolution. This method, sometimes called half-sizing, is perfect when we intend to rescale the image to CIF of lower resolution in our problem.

### .3.6Aspect ratios

As we noticed in previous sections, nearly all the mobile TV handsets are designed to display resolutions with traditional 4/3 aspect ratio. However many SD contents and all the HD contents are now prepared with widescreen aspect ratios like 16/9.

There is no magic trick to preserve wide screen aspect ratios on mobile TV: we have to use the same good methods used to display 16/9 contents on 4/3 TV set : letterbox or pan and scan method.

Letterbox is the simplest method: we simply adds black bars at the top and the bottom of the picture. All the image is preserved but we can easily imagine that having 2 black borders on a 2 to 3 inches LCD screen is a real waste of space.

The famous pan and scan method consist in intelligently panning and scanning horizontally across the widescreen film to keep the action in the middle of the screen. This avoid wasting some screen space but this results of 30% of the original image loss.

### .3.7Small zone but big impacts

In most of TV images, some small area of images are very important for content producer and may require particular attention when repurposing the images. It is very common to have a TV channel logo in one corner of the image. Many programs include banners too or other meta information like score tables or timers that are crucial in the broadcast program.

When images are prepared for mobile TV, we have seen that the image may be resized or cropped to adapt to the mobile world. When logos or score tables need to be preserved, some particular processing may be put in place.

A simple method is just to avoid removing these informations. We can always adjust the cropping and framing algorithms to always keep such zone. So regions containing critical informations just become image boundaries for image adjustment algorithms.

In addition to simply preserve small part of images, it is often very important to ensure that logos or scores are transmitted with the best quality. For this purpose, it is possible too to use new compression standards to ensure that small area of the images are partially independently considered and encoded with a good and constant quality even if the global image is getting lots of motion and so compression artifacts.

# Conclusion

We went through this document to all the major aspects to deal with when we intend to repurpose existing digital TV contents to a mobile networks. From the video standards to the audio mixing issues, we now have concrete solutions to provide the best user experience when watching Mobile TV contents that have been repurposed from current TV networks.

# About the authors

**Regis Le Roux - President and Chief Executive Officer**

*He started his career at Wandel&Goltermann (today known as JDSU), as Product Manager for the Digital Product range and introduced the first Acterna's Real-Time transport Stream analyzer on the market. In 1999, Regis joined Thomson Broadcast Systems as System Solutions Manager. He was then hired by TDF as Marketing & Sales Manager to study the launch of new MPEG-2 monitoring methods. In addition to his INSA degree, Regis holds a Master's of science in Telecommunications from the University of Strathclyde, in Glasgow, Scotland, and a Masters of Business Engineering from the Ecole Nationale Supérieure des Télécommunications (ENST) de Bretagne, France.*

*In 2004, he founded ENENSYS with two fellow experts and now manage a 65-people business which offer ranges from Mobile TV and Digital Terrestrial TV infrastructure to Test & Monitoring solutions, with high grade services and trainings.*

**Yannick Le Duc - Product manager – Digital Turn Around**

*He began working in Digital TV in 1999 at France Telecom R&D labs, then joined Envivio, a France Telecom spin-off in 2000. Later on, he was Project Director in R&D in charge of the encoder product line and notably of the Mobile TV product line. He joined ENENSYS Technologies in 2007 and he is now in charge of the Enensys "Mobile TV transcoder" (TransCaster) and the Digital Turn Around product line.*

# About ENENSYS Technologies SA

ENENSYS has years of experience in Digital TV transmission systems design and manufacturing. Offer ranges from Mobile TV, Digital Terrestrial TV, IP Distribution to Test & Monitoring solutions, with high grade services and trainings. Covered standards include DVB-T, DVB-H, DTMB, MediaFLO, Digital Cable, 8-VSB...

With more than 200 customers on 50 countries, ENENSYS clients are Broadcast Operators, Network Operators, Telcos, TV Channels, Chipset Vendors, Set Top Boxes Manufacturers, Professional Equipment Manufacturers and System Integrators.

Headquartered in Rennes, France, in the heart of the European Digital Broadcast Cluster, ENENSYS is publicly listed on Euronext Paris Stock Exchange (FR0010286252 – MLENS).

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