DVB SUBTITLING IN AN OPEN ENVIRONMENT

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ABSTRACT

The introduction of Digital Terrestrial Television in the United Kingdom has provided an excellent opportunity to enhance the quality and number of ancillary services such as subtitling (closed captioning).

This paper describes the requirements of subtitling in UK DTT, the development of a consensual UK profile for subtitling with its inevitable compromises, how interoperability has been tested and how the BBC have implemented DVB subtitling.

INTRODUCTION

Analogue television in the UK has long made use of teletext to deliver subtitles (closed captions) to the domestic display.

The introduction of Digital Terrestrial Television (DTT) in the United Kingdom has however provided an excellent opportunity to enhance ancillary services including subtitling. To this end the UK Independent Television Commission (ITC) have mandated that DVB subtitling be used for UK DTT.

With UK DTT based on open markets for coding and multiplexing equipment, for modulation, delivery and for subsidised and independent DTT free-to-air receivers it has been essential to ensure interoperability.

Integrating the new technology with existing subtitling infrastructures has also presented new challenges.

THE BENEFITS OF DVB SUBTITLING

DVB subtitling [1] defines a means of conveying region-based bit-mapped graphics as MPEG-2 packetised elementary streams (PES). The bit-mapped pixel images are run-length coded and transmitted along with colour look-up tables (CLUTs) to the decoder where the stream is decoded and the images rendered into the on-screen display (OSD).

The use of bit-mapped images allows the broadcaster to determine the look-and-feel of subtitles, to use proportionately spaced and anti-aliassed characters and (within limits) to be able to trade image quality or image complexity for bit-rate[1].

The PES packetisation process provides the means by which subtitles may be presented by the decoder co-timed with the video and audio via the standard MPEG time-stamp mechanism.

For users of subtitles (especially those with visual impairment) one significant benefit is that it has been possible for the UK ITC to mandate the use for subtitling on UK DTT of a font called Tiresias. This font has been designed specifically for the visually impaired for its legibility when used with electronic displays [2]. The result is subtitles that are visually attractive and easy to read. In the UK the size of Tiresias font used is between 22 and 24 frame lines capital V height.

THE DEVELOPMENT OF A UK PROFILE

As implementation of DVB subtitling encoding and decoding progressed in the UK during 1998 it became clear that some modest pragmatic constraints and additional features needed to be applied to the DVB specification if an open system for subtitling was to be practicable. The UK Digital Television Group (UK DTG) - representing broadcasters, multiplex operators and manufacturers - has derived a UK Profile for DVB subtitling which is described in the “D-book” [3]. Many if not all of these features will be applicable to all potential users of DVB subtitling.

If subtitling is to appear on the screen concurrently with an MHEG application it is necessary to coordinate use of the CLUTS so that

[1] This is in contrast to teletext subtitling where in practice the visual effect is prescribed by the various teletext decoder implementations and results in coarse mosaic letterforms.

painting a new subtitle does not change the rendition of the MHEG graphics and vice versa. DVB subtitling can make use of up to 256 colours each of which may be (more or less) independently defined. The colours are indexed by colour number and the CLUT defines the mapping of index to Y,Cr,Cb and transparency values for those colours which have been used in the region to which that CLUT applies. Subtitles and MHEG applications will generally have been authored independently so the solution chosen by UK DTG has been to specify that, if subtitles and MHEG applications are expected to coexist in an OSD image, then subtitles must restrict themselves to colour indices 0 - 63 (with notional free choice of displayed colours within that index range) and MHEG applications can freely use colour indices 64 - 255. Where concurrency is not required there are no index limitations.

The profile also places practical limits on the number of regions which may defined in an epoch and on the number of objects within a display set. Furthermore in the UK we will not be using 2-bit coding. These constraints facilitate decoder implementation but have little impact on subtitling in practice.

Additionally a new optional **end_of_display_set** segment construct has been defined which allows decoders to comprehend when reception of a display set is complete and they can safely start to decode as soon as possible.

The colours presently in use in the UK for DVB subtitling are derived from those used for teletext (i.e. white, red, green, blue, yellow. cyan and magenta). In teletext subtitling colours are used to distinguish different speakers or to highlight sound effects. With one transparent value and 7 "grey" levels for each colour it is possible to present pleasing antialiassed letterforms of any of these colours in one region and within the 0 - 63 colours constraint mentioned above [4]. In practice subtitlers rarely use more that 2 or 3 colours in any one row of subtitles, a row is rendered as a region and each region can have its own different CLUT so the constraint is not a significant one.

Subtitles are rendered into the on-screen display memory of the receiver. In a set-top box the osd. is inserted downstream of any video processing designed to match the video to the display (e.g. by using **active_format_descriptors** or AFDs [4, 5]). Subtitles are therefore painted "onto the glass" and are invariant to the set-top box display modes where these are implemented within the box.

THE DYNAMICS OF SUBTITLING

The dynamics of subtitling are of considerable importance to testing interoperability, to bit-rate management and to monitoring.

Unlike video and audio, subtitles are **extremely** "bursty" in their arrival time at the coder. The dynamics vary from one programme to the next, from one programme genre to another and from one broadcaster to another. It is therefore very important to ensure that coders can accommodate the variance of coding load, that the multiplex can provide the bit-rate as required and that decoders can deal with all types and conditions of subtitling.

- Pre-prepared subtitles are generally in block form - one, two or three rows of subtitle appear simultaneously and then linger on screen long enough to be read by the target audience (typically between 3s and 5s but up to 10s). When coded these large objects require a high peak bit-rate to which is associated a very low (zero) minimum bit-rate during the reading time. "Add-ons" which are used to distinguish between different in-vision speakers are sometimes used especially for "TV soaps" and these reduce the variance in bit-rate somewhat. As time has been allowed for reading the whole subtitle a modest delay in delivery of block subtitles to the display has less impact than for live subtitling.

- Live subtitling in the UK usually involves breaking the text to be shown into elements row-by-row or even word-by-word and transmitting the elements as they are interpreted and typed by the stenographer. When a new row is complete it scrolls up allowing space for the next revelation. This allows each word, phrase or row to be transmitted as a single object – the volume of run-length data to be transmitted for a phrase is much smaller than for a three-row block subtitle but the transmission of one phrase is followed shortly by the next. In principle a completed row may be scrolled by instructing the decoder to perform a region-move – a process requiring little data compared with transmitting the completed row. In practice the misspellings or misinterpretations which inevitably occur in stenographic subtitling can be corrected if the complete and corrected row is retransmitted as a new entity. Inactivity is relatively rare during live subtitling so the variance in bit-rate is less than for block subtitling although the peak rate may be similar. Late delivery of live subtitling (e.g. due to slow coding, insufficient transmission bit-rate or late rendering in the decoder) has a greater impact on readability than for block

subtitles. Note that live subtitling always incurs some delay since it requires intelligent "look-ahead" on the part of the stenographer before the context can be gauged and the correct word typed.

- Some live programmes combine pre-prepared subtitles manually triggered with stenographic subtitles. In this case the variance in bit-rate will change programme item by programme item.

- Some programmes have significant periods during which there are no subtitles (e.g. where there are explanatory graphics in vision or whilst there is no dialogue).

- Some programmes have no subtitles at all; for these a "holding" caption or icon may sometimes be transmitted (albeit infrequently) to tell the viewer that subtitles are not available for the current programme.

Figure 1 shows the bit-rate requirements for subtitling 10 minutes of a typical TV soap - "Neighbours"- with pre-prepared subtitles. The bit-rate is averaged over each second. The coding used Tiresias 22 line capital V height with 7-level antialiassing (i.e. 4-bit coding was usually applicable). Figure 2 shows the bit-rate requirements for live subtitling a news programme under the same conditions. This live subtitling used what we call "snake" subtitling in which the subtitle is transmitted word-by-word and appears cumulatively. The different dynamic requirements are clearly visible.

INTEROPERABILITY

UK DTT signals from the various multiplex operators are presently coded using AV coding equipment from at least four different manufacturers and using DVB subtitle encoders from two other manufacturers. The signals are then being decoded by set-top-boxes and integrated receivers from a number of different manufacturers so it has been a considerable challenge to ensure interoperability for DVB subtitles alone.

Before the launch of UK DTT development of subtitle encoders was only just more advanced than that of decoders; initially therefore test streams with software-encoded subtitles were distributed to check basic functionality (colour interpretation, common understanding of syntax etc.) and to identify issues relating to particular decoder implementations. Once subtitle encoders were able to provide real-time coded streams we were able to distribute test streams representing the dynamics of real subtitles from several combinations of coder manufacturer albeit restricted by the length of stream which can be recorded on a CD-ROM. As stable decoder software became available three labs representing UK multiplex operators (at ONdigital, BBC R&D and ITV Technology Centre) ran soak tests on representative decoders to tease-out residual problems before the various elements of the system were deemed to be ready for over-the-air use in January 1999. Throughout broadcasters, coder manufacturers and decoder developers worked hard together and the results represent a considerable collaborative investment in effort and accumulated experience.

Ultimately the only practicable method of testing the end-to-end system fully under all representative conditions and subtitle dynamics has been to do so over-the-air. Test streams for subtitles are inevitably limited to providing short "snapshots" of what is a complex and time-varying process.

As noted above the bit-rate requirements for subtitling can vary greatly over short and long periods of time (0 - 192 kbits/s). Almost all contemporary coding and multiplexing systems require the user to assign sufficient bit-rate for subtitling an event (e.g. a particular programme) and this bit-rate is "locked-off" for the duration of the event. In practice the value assigned must be chosen to match the peak requirement - at all other times the bit-rate will be under-used. This is wasteful of bit-rate (although some downstream multiplexing strategies may be able to reuse any resulting null packets). It also complicates management of bit-rate across a number of services. A highly desirable feature of future systems will be to allow subtitles (and other bursty service components) to be opportunistic. Given the relatively modest bit-rate requirements involved one strategy would be to guarantee a low bit-rate (e.g. 10 kbits/s) and to take any more bit-rate *opportunistically* from the video for that service. Another approach would be to include subtitle and data services in the variable bit-rate pool of statistical multiplexing systems.

One element still missing from the subtitle signal chain is the ability to decode DVB subtitles from a baseband stream for monitoring purposes. It is to be hoped that various manufacturers are addressing this requirement with cost-effective solutions that work with real subtitle streams.

A pragmatic feature of subtitles which doesn't fit comfortably with some models of transport stream monitoring is that with some programme material there are reasonably long periods of time for which there is no reason to send subtitle data at all. It is therefore entirely reasonable to have the

subtitle stream referenced in the Programme Map Table (PMT) and yet for the period concerned to detect no packets with the subtitle stream **packet_id** (PID).

DVB SUBTITLING IN THE BBC

The BBC now subtitles 55% of its BBC ONE and BBC TWO output and at least 5% of programmes on its new digital channels. As part of the BBC's commitment to public service broadcasting it is planned that these figures will rise year by year to a target of over 80%. However in common with other broadcasters and multiplex operators ancillary services such as subtitling generate no additional income so cost-effective end-to-end solutions are essential.

The pre-existence of infrastructure and operational procedures for the preparation and playout of teletext subtitles has thus led the BBC to use teletext in the vertical blanking interval (vbi.) of serial digital video (SDV) as the transport mechanism for subtitles from playout to emission coding for its digital services. Because subtitling is an component of most TV programmes, the BBC tries to ensure that the subtitles are included with the video and audio at the earliest opportunity

Subtitles are inserted into the SDV in one of three ways shown diagrammatically in figure 3. Pre-prepared subtitles for commissioned programmes are played-out from digital video tape recorder or server (with the subtitles as teletext already in the vertical blanking interval) or they are inserted at the time of playout downstream of the vtr/server from a subtitle server/inserter triggered by timecode. In this case the subtitle server is programmed from files delivered on floppy disk in the EBU subtitle file format [8].

Subtitles for live programmes are generally inserted further downstream after the presentation mixer either from stenographic input (e.g. really live) or manually triggered from EBU file (pre-prepared live).

Once the teletext subtitle signal has been combined with the vision signal for the appropriate service it can be routed to the appropriate emission coder in an "N+1" redundancy arrangement.

The BBC is however both a national and a regional broadcaster delivering nationwide and regional content on an increasing number of digital services. To deliver these services the BBC has built a complex distribution network the architecture for which was reported at IBC '98 [6]. Services with regional content are coded locally – the nationwide material for regional programmes to opt away from is conveyed on ATM bearers to the region as "sustaining feeds" having been coded in London as MPEG MP@ML at just less than 10 Mbits/s. At the regional centre this sustaining feed is decoded, regional content added (opting) and then coded locally at the lower emission rate. Local subtitles are also inserted; switching subtitles as teletext in the vbi. with existing technology is the only option presently available so the incoming sustaining feed conveys subtitling information for the national programme material encapsulated as DVB teletext in PES packets [7] - see figure 4. This allows the timing relationship between subtitles and video/audio to be maintained on the sustaining feed.

For emission coding the teletext subtitle is parsed by the DVB subtitle encoder, interpreted and rendered as a (notional) pixel image before coding. The BBC uses two vbi. lines per frame for subtitling which helps to reduce the time taken code a subtitle.

In the encoder the teletext colours are mapped to matching Y,Cr,Cb values. Mapping teletext characters based on a fixed character tile size to an image built from proportionally-spaced antialiassed Tiresias is less straightforward.

The BBC uses third party subtitle encoders which insert a coded and encapsulated subtitle stream via TCP/IP into the associated AV coder.

CONCLUSIONS

The process of ensuring interoperability for DVB subtitling in an open DVB system has required considerable effort and cooperation. The result of this teamwork is that DVB subtitling is in widespread use in UK DTT, generated by various combinations of subtitle coder and AV coder/multiplexer and decoded on diverse receiver implementations.

We continue to find many uses for the vertical blanking interval - conveying subtitle information is one, using SMPTE RP186 video index another. It is easy to ignore or mistreat the vbi. of digital video but it continues to provide a valuable resource for solving a wide range of problems. Manufacturers should ensure that the integrity of data inserted in the luminance or chrominance of the vbi. of serial digital video is respected.

The bit-rate requirements for DVB subtitles vary substantially from second to second and from programme genre to programme genre. We look forward to being able to use opportunistic data multiplexing techniques to make more efficient use of our bit-rate.

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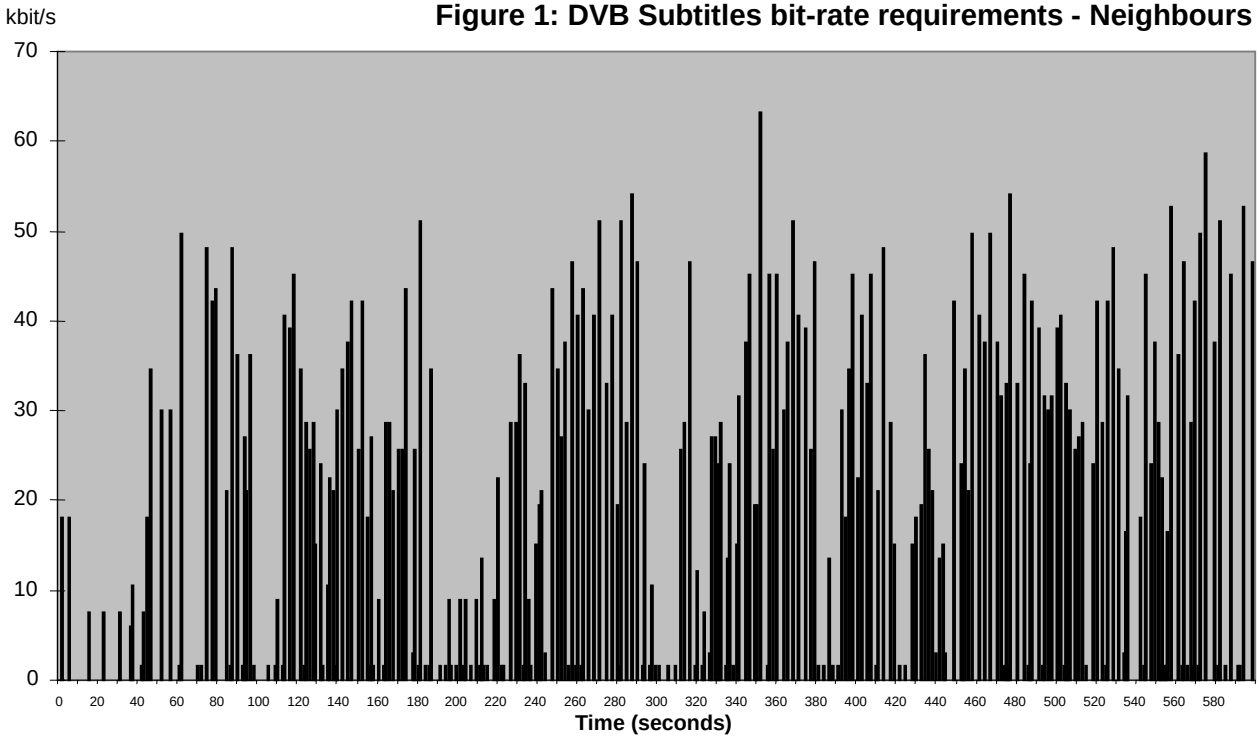

Figure 1: DVB Subtitles bit-rate requirements - Neighbours

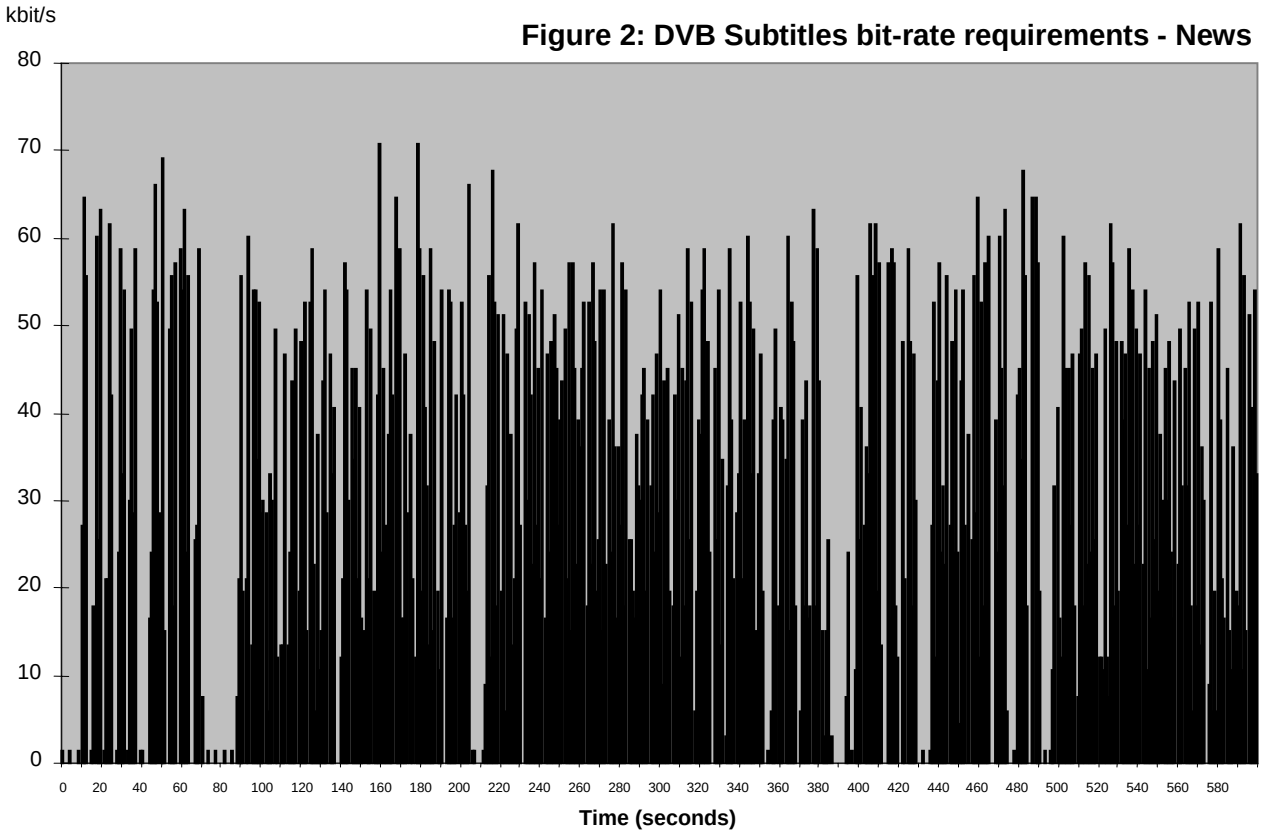

Figure 2: DVB Subtitles bit-rate requirements - News

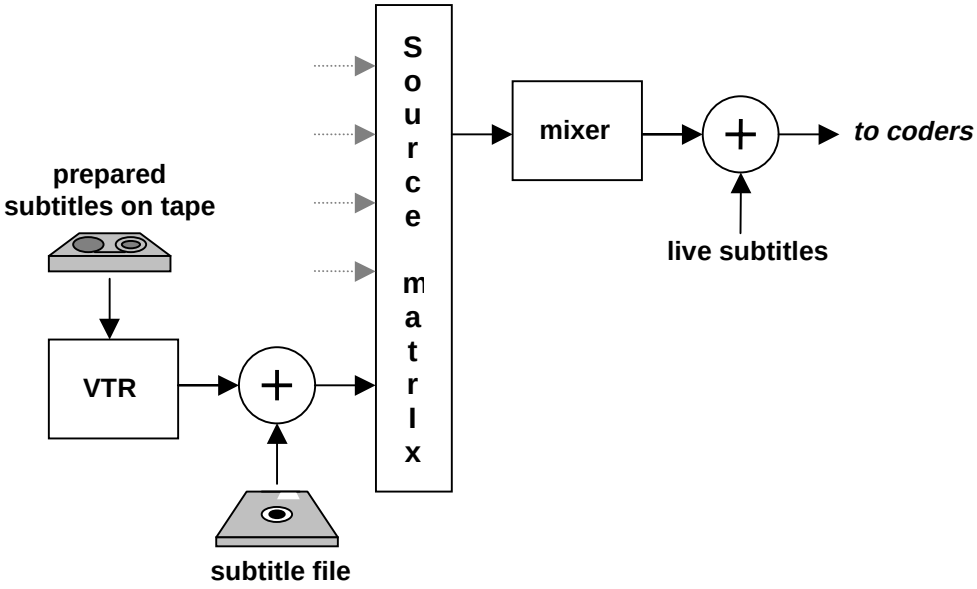

Figure 3 : Subtitle insertion points within the presentation suite

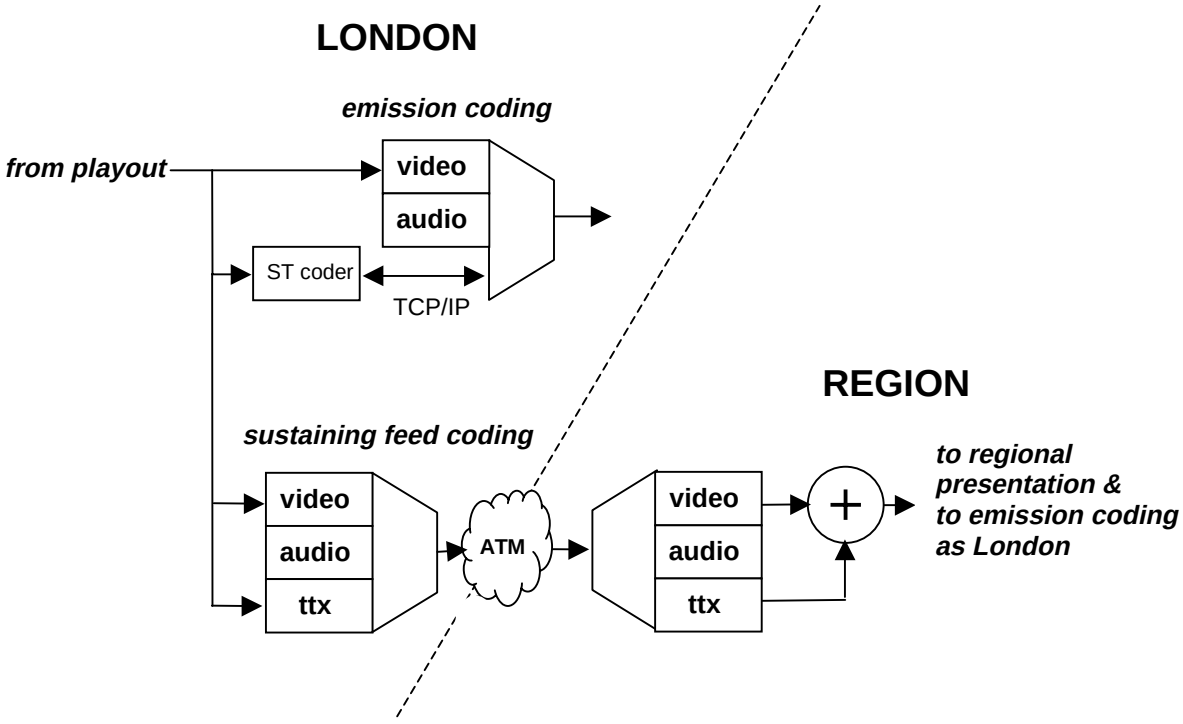

Figure 4 : Subtitle encoding for national and regional programmes