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INNOVATION REPORT

HD4U: a European HDTV platform

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With high definition television (HDTV) being rolled out in the USA, Japan and other major countries in Asia, it appeared crucial for European companies to be prepared for HDTV deployment. For that purpose the HD4U project has gathered major actors of the European HDTV world with a twofold objective: to fill the technological gaps in the HDTV chain and to demonstrate HDTV experience in a real environment over satellite, wired and terrestrial networks.

New usage and user requirements in the broadcast HDTV domain

Figure 1. Moving from standard to high definition TV

Launched in Europe in 2004 by Euro1080, HDTV is distributed today over more than 30 satellite channels and is expected to move quickly towards terrestrial and IP networks. Major worldwide events have induced a noticeable step forwards to HDTV production and distribution. Initiated by the 2006 World Cup, HDTV deployment in Europe should be confirmed by the Olympic Games in 2008.

HDTV obviously attracts consumer interest with the new appealing audio-video experience it offers – see Figure 1 – and by the tremendous technological efforts to make the price of large flat screens affordable for the consumer market.

The attraction for HDTV should however be consolidated to maintain the demand at a sufficiently high level that enables European manufacturers and operators to recover rapidly the noticeable investments required for large-scale HDTV deployment. Such a consolidation must take the following aspects into account:

- Speed up deployment of HDTV services on all networks by developing solutions for various network technologies – satellite, digital terrestrial television (DTT), Internet protocol television (IPTV), etc.;
- Increase the number of HDTV programmes per transmission channel to propose a substantial commercial offer on the existing infrastructure – this requires a breakthrough in HD distribution bitrate possible with MPEG4-AVC compression technology; and
- Enhance the broadcast end-to-end quality of experience to compete efficiently with Blue-ray DVD quality. Objective quality algorithms based on the human visual model and implemented before the compression stage (pre-processing) and before display (post-processing) must be envisaged.

To boost the advent of HDTV in Europe, the HD4U project focused on the development and demonstration of the key technological components missing in the HDTV chain – see Figure 2.

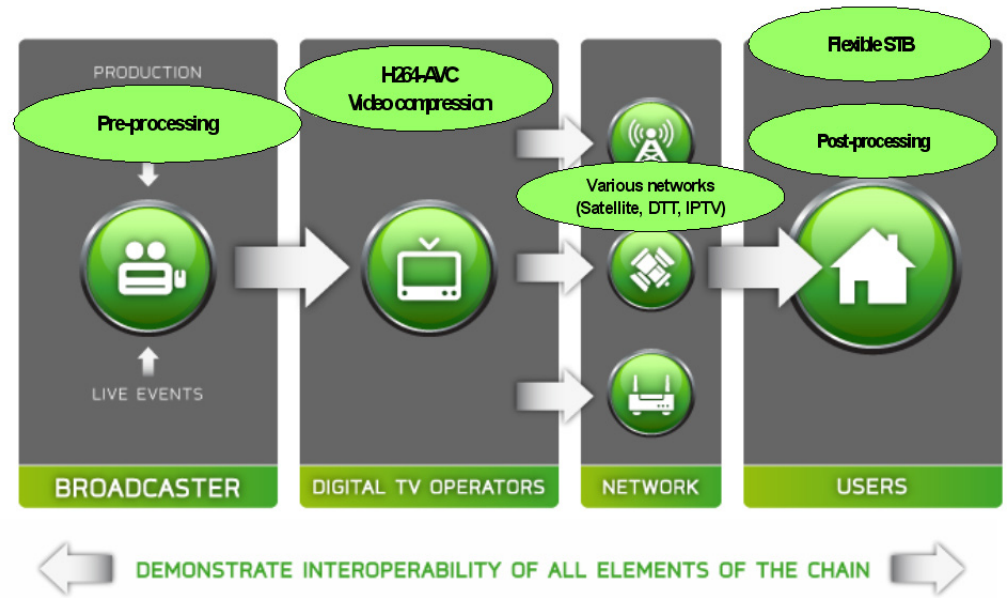

Figure 2. Demonstrating the complete HDTV chain

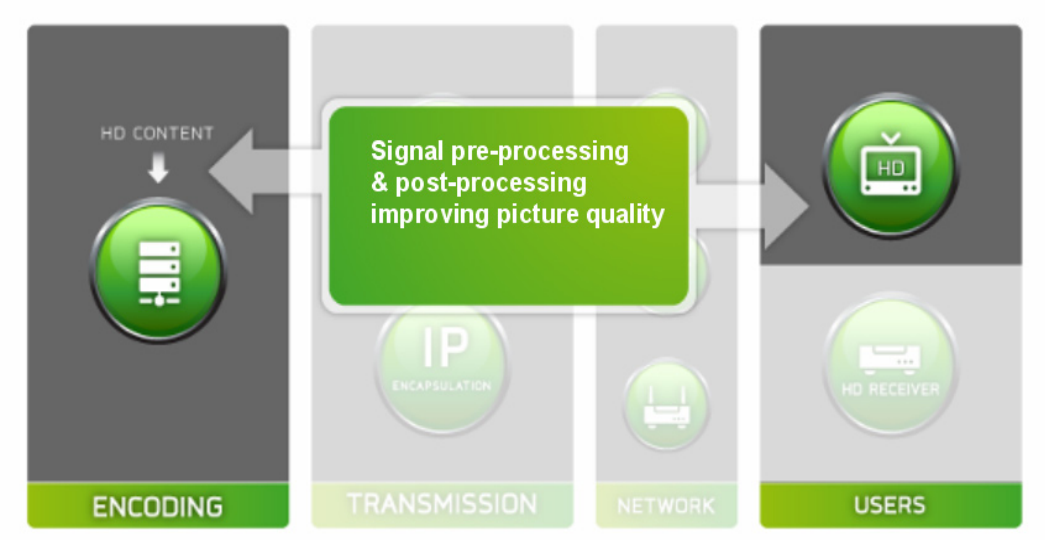

Figure 3. Enhanced video codec

Main challenge: video compression

One of the main technological steps tackled by the project was to move from MPEG-2 to the latest H.264/MPEG-4-AVC video-compression standard to save 20 to 30% bitrate by using a first generation of real-time HDTV encoders. In addition, HD4U demonstrated further improvements can be carried out in extending the video-compression mechanism with appropriate pre- and post-processing, as illustrated in Figure 3.

This involved the study of:

- Pre-processing techniques to improve the correlation inside and between pictures and to make the compression more efficient;
- Pre-analysis techniques to adapt the encoding strategy dynamically to the content – the H.264/MPEG-4 AVC video-coding standard provides numerous tools that an encoder has to select to achieve high performances properly;
- Optimisations in the encoding loop to increase the compression ratio; and
- Different post-processing techniques as complementary solutions to the overall transmission system to improve the subjective quality of the content for the final users.

Making use of these improvements, a significant bitrate reduction can be anticipated with the coming second generation of video encoders. Improvements are expected from the 20 to 30% bitrate saving achieved with the existing first generation of encoders compared with the MPEG-2 standard, to now more than 50% in the short term, as shown in Figure 4.

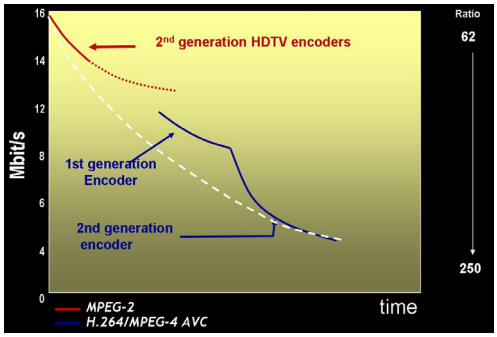

Figure 4. Prospective bitrate evolution for HDTV

As a result, HDTV at 6 Mbit/s is forecast in the midterm for broadcast applications. HD4U experimental results on the three transmission media show that this estimation is realistic:

- Satellite: Euro1080 achieved a 55% bitrate saving per satellite transponder by using the first-generation H.264/AVC video compression associated with DVB-S2 satellite modulation;
- Digital terrestrial: TF1 plans to launch three HDTV services by the end of 2007, using the French digital terrestrial broadcasting channels; and
- xDSL: MaxiSat carried out field trials on ADSL2+ in Finland and reported that more than 90% of its customers can receive at least one HDTV programme.

New challenge: HDTV picture quality assessment

Within the HD4U project, several innovations have been developed concerning subjective quality assessments in three different areas:

- Subjective assessment tests to evaluate the perceived quality of the HD4U HDTV transmission chain by real users;
- An extension of existing models of human visual perception; and
- A new objective quality criterion to provide quality values to replace time- and cost-consuming quality assessment tests.

To measure the performances of the HD4U broadcasting chain, the project extended ITU recommendation BT.500-11 for SDTV resolutions towards HDTV on the following aspects:

- The testing conditions – process, session and observer instruction;
- The test environment – viewing condition, display settings and sources; and
- The objectives – bitrate quality test, format comparison test and display quality tests.

In addition, some psychophysical tests made it possible to measure the perceptual impact of the new liquid crystal display (LCD) technology which is the most deployed today for HDTV screens. Motion blur, which is the main defect of LCDs and which does not exist on cathode ray tube (CRT) displays, has been described, explained and subjectively studied; and a new innovative model has been proposed for motion-blur measurement. The model has been validated with results from real

observers.

Finally, a video quality metric has been designed to predict the subjective quality judgment for a given video content at a given bitrate.

HD4U: a booster for HDTV in Europe

Three complete transmission chains – terrestrial, ADSL and satellite – have been set up in the HD4U project. Demonstrations showed HDTV broadcast is now ready for deployment in Europe and that the coming next generation of equipment based on MPEG4-AVC technology promise a target bitrate of 6 Mbit/s.

HDTV commercial deployment is possible now

The number of HDTV programmes per transmission channel that can be expected in the near future is given in Table 5, based on the technological forecast and the following project results:

- Euro1080 today broadcasts four HDTV programmes over one transponder of EUTELSAT W3A at 24 MHz and three HDTV programmes over one transponder of ASTRA 1D at 18 MHz.
- MaxiSat made field trials on ADSL2+ in Finland and reported 75% of its clients have access to 14 Mbit/s bandwidth, while 93% of its clients are less than three kilometres from the DSLAM with up to 8 Mbit/s bandwidth. In such cases, ADSL2+ and H.264/AVC are able to provide one or two HDTV programmes over Internet networks.

Medium	Channel bandwidth	#HDTV programs
ADSL2+	20 Mbps	3
DTT	24 Mbps	4
Cable	38 Mbps	6
Satellite	50 Mbps	8

Table 1: Number of HDTV programmes per transmission channel

Table 1 shows that a commercial exploitation of HDTV is possible now with current transport and broadcast architecture.

New methods are ready to improve HDTV picture quality

User-experience analysis in the project shows some elements of the HDTV transmission chain are in an early stage of operation and are still open to improvement in the near future. In particular, tests on motion blur show LCD screen defects are an important issue. This characterisation has made it possible to measure the impact of some processing techniques which aim to reduce the motion-blur effect – such as grey-field insertion, black-data insertion, scanning backlight or frame interpolation. The improvement algorithms studied in the project are now sufficiently mature to be implemented in the next generation of encoding/decoding equipment.