Final Version of Terminal Device

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Abstract: This report describes the design and implementation of the final version of the terminal device. This version integrates the new generation NEC auto-stereoscopic LCD and a new receiver antenna. 3DTV application is developed to demonstrate the features of the device. The software includes additional drivers for NEC LCD and support for streams with corresponding resolution 640x360x2. The device was demonstrated at the ICT Event 2010 in Brussels 27-29 September 2010. It is the final form factor of the mobile device, and this version includes all components of the final system.

Keywords: OMAP, DVB-H, auto-stereoscopic LCD
Executive Summary

The final version of the terminal device (prototype) is developed. It includes a reworked platform and has the form factor and the functionalities of modern PMPs (Portable Media Player) and also additional features as auto-stereoscopic LCD and DVB-H receiver.

From HW perspective, several new components were developed and produced:

- The new version of the auto stereoscopic LCD (NEC) module was developed and integrated.
- The new version of the processing platform (OMAP3621) in final form factor confirming the requirements of the modern consumer.
- The housing for the device is designed and stacked up.

Key SW components and tools have been ported and used to support this version of the mobile terminal device. Those are the platform-specific operating system, file system, tool-chain, DVB-H low level drivers, new auto-stereoscopic LCD drivers and a multi-view decoder based on H.264 decoder. The selected OS is Poky Linux for OMAP3 platforms, because current Android releases do not support TV streaming as components. New 3DTV demo application is developed to demonstrate the device capabilities. That version was demonstrated at the ICT Event 2010 in Brussels.

After ICT Event additional features to the final terminal version are included - new housing, internal antenna, new battery pack with higher capacity, additional improvement of the software package. Due to the hardware changes and the delays in antenna devices receiving, the final release of the terminal device was launched in February 2011.

New HW and SW components have been integrated in order to accomplish the targeted version. After integration, the device software provides the capability to decode and render stereoscopic video content in MVC from stored files or received via the DVB-H (DVB-T) broadcast.
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1 Description of the final version of the mobile terminal device

1.1 Form factor of the terminal device

For the final version of the terminal device MMS has developed a new portable platform to improve the form factor of the device. It is a PMP (Portable Media Player) device, with all the additional features needed for the Mobile 3D TV project. The final version of terminal device is shown in figure 1.

![Figure 1. Final version of 3D terminal device](image)
The device platform has been reworked. The dimensions of the PCB are 100x52mm which gives the device modern form factor.

The display used in this version of the device is an improved version of the NEC auto-stereoscopic display. The new design includes an interface board. The interface board is stacked between the display and the main PCB.

1.2 Final mobile terminal device HW features

The device HW incorporates:

- Developed by MMS processing platform (OMAP3621, 2Gb LP-DDR, 16GB eMMC);
- NEC Stereoscopic Display Module
- DVB-H receiver chip from Dibcomm
- Battery and wall adapter power
- Integrated audio system
- Navigation buttons
- Connectivity options – WLAN, Bluetooth, FM, UART, USB host and function
- Debug interfaces – JTAG, UART

1.3 Final mobile terminal device SW support

The final version of the device supports Poky Linux platform for OMAP3 devices. The team have designed the drivers required for the hardware operation and also ported the Poky to the device. The device has fully operation Poky GUI with all features available in the OS.

Developed modules and new porting for final version of terminal device:

- Linux – Poky for OMAP3 devices
- Keyboard driver
- Dibcomm low-level drivers modifications
- NEC display driver
- 3DTV GUI application
2 Auto-stereoscopic display

In this version of the device new improved version of NEC auto stereoscopic display is used. This display gave best characteristics in the tests and also has a good form factor.

The display is in production and has the following characteristics:

- Mobile form factor – 3.1"
- Good resolution - 640x360 pixels in 2D and 3D modes
- Modes of operation - 2D and 3D modes, software switchable
- Low power consumption
- System interface - 24bit parallel RGB
3 Design of the processing platform for the final mobile terminal device

3.1 Design of the processing platform
Block diagram of the device is shown in Figure 5. This diagram shows the main features of the device.

The selection of the processor was discussed in the previous deliverable.

Full schematics of the device are attached to the report.

3.2 Additional features
The version version of the device combines the third version SOM module and mainboard, in one single board with better form factor. Some additional features are added, which are presented in the modern devices.

Additional features are:

- Audio module – Low-Power Audio Codec With Embedded miniDSP and Stereo Class-D Speaker Amplifier
- Battery charger and Li-Ion battery – to assure the mobility of the device
- W-lan
- Bluetooth
- FM radio
- USB Battery charge
- Microphone – for voice recording.
Figure 2. 3D TV player block diagram showing the main features
4 Housing of the third mobile terminal device

4.1 Housing requirements
The main requirement for the housing at this stage is the form factor.
The housing must hold in the whole stack including the battery, PCB, NEC display module (interface board and display). Holes for all plugs (USB, stereo phones, microphone, etc) should be considered in the design.

4.2 Design of the housing
MMS will develop plastic housing for demonstrations, after the final stack height is considered.

Figure 6. Housing of the prototype
5 The device for the ICT Event

The demonstration of the device at the ICT Event in Brussels, September 2010 has been set as a major milestone within the project. At the time of the event the device supported the following features and the corresponding GUI:

- Select TV program – Animation, Documentary, Sport
- Play different programs

Figure 7 illustrates the GUI

![Figure 7. Housing of the prototype](image)
6 Final terminal version

6.1 Final Terminal Housing

The final housing was developed after the ICT event with the aim to restrict the access to the terminal interior parts and thus to make the device more suitable for field testing.

![Figure 8. Final housing of the prototype](image)

6.2 Final terminal antenna equipment

Earlier versions of the prototype were constructed with external detachable DVB-H antenna. New DVB-H antennas were procured from a supplier, designed to be soldered on the PCB. This required some constructive changes related with the PCB and the housing. Figure 9 shows the new antenna.
6.3 Final terminal battery pack

After initial testing of the prototypes, power consumption and battery charging problems were encountered. The need of an extended battery work was addressed by a new battery pack: It is now included in the device and is capable of supplying up to 10 hours of operation.
6.4 Software developments

6.4.1 View plus Depth Decoder

Video plus depth (V+D) decoder and renderer were implemented using as a base the algorithms developed by the partner FHG. The decoder decodes such type of 3D video based on MVC decoder. In the V+D decoding, the primary view is transmitted as a separate stream and the additional depth data from which the secondary view is generated is transmitted as an additional stream in the MVC NAL stream as shown in Figure 11.

![Figure 11. NAL ordering for Video plus Depth transmission](image)

Thus, the developed MVC decoder was reused to handle V+D. A rendering step is required after both the view and the depth frames are decoded. The algorithm structure for the renderer was supplied by HHI and is shown in Figure 12.

![Figure 12. Rendering algorithm structure](image)
The algorithm consists of the following general steps:

1. The decoded base view is obtained
2. The depth data for the secondary view is obtained
3. Based on the depth data, disparity data is generated. The disparity map simply represents the number of (fractional) pixel positions that any pixel from the base view has to be shifted to in order to generate the secondary view.
4. The disparity map is applied to the base view and a preliminary secondary view is obtained by shifting the rows by factors driven by the disparity values.
5. Once the preliminary secondary view is obtained, fill holes caused by dissocclusions is needed. Border effects are encountered as well.
6. Border effects in the secondary (generated) view are handled by copying the last available pixel data in each row. This fills the missing border pixels with some meaningful data.
7. Dissocclusions are tackled by copying and fusing nearest available pixels as suggested in the FHG’s algorithm.
8. The obtained secondary picture is additionally filtered in order to improve the overall appearance.
9. The output of the renderer is passed to the higher level software layers.

Because of the additional processing necessary for the renderer implementation, the overall picture processing speed is presumably lower. The supported rate is 15fps and the resolution is 480x360x2 for stereo frames.

### 6.4.2 MVC Decoder Enhancements

The NAL (Network Abstraction Layer) bitstream for MVC is more complicated than the one for AVC. Some NAL units (SPS, PPS, etc.) must be repeated in order to provide decoding parameters for both views. Additional features are added in their frame structure. New NAL units are added such as the Prefix NAL unit which precedes each new access unit. Reordering of the reference pictures of both the base view and the secondary view is supported.

In order to meet these new requirements the NAL layer decoding has been amended. Decoding for the new NAL units has been implemented. The existing NAL unit syntax has been expanded, queuing allowed for the secondary view data and the reference picture lists (lists of decoded pictures used for reference during the decoding of a new picture) have been improved. Once the reference picture lists have been set up, the DSP processing for MVC adheres to the AVC
structure. The Baseline profile has been implemented. This requires only “I” (intra-picture prediction) and “P” (inter-picture prediction) pictures availability. Two types of coding schemes have been tested. In the first, both the base view and the secondary view start with an intra-predicted picture (“I” picture). In the second one only the base view starts with an “I” picture whereas the starting picture of the secondary view is inter-predicted from the base view (“P” picture). Block schemes are given below.

As can be seen from the above figures if for some reason we obtain an incorrect frame data from the channel we will be unable to decode and display all the frames up to the next “I” frame (“I” frame data is self-contained). For this reason once the decoder finds faulty data in a frame it stops the subsequent frame processing and output until an “I” frame is obtained. Once the next “I” frame is found the data processing is resumed. This is the easiest and probably the most effective way to handle frame loss. The effect for the viewer will be just a short freezing of the video picture. An example is shown in Figure 15.
Furthermore, special care has been taken to synchronize left and right frame at socket level.

### 6.4.3 Video and Still Pictures Support

In addition to MVC and V+D, conventional simulcast (side-by-side) support for AVI and MPEG4 containers has been added and support for picture formats such as PHG and JPEG has been added as well.
7 Conclusions

- MMS developed and produced the final version of 3DTV terminal device
- The partners demonstrated the 3DTV terminal device on ICT Event 2010 in Brussels
- The release of the last version of terminal device was accomplished at the end of February 2011.
MOBILE3DTV - Mobile 3DTV Content Delivery Optimization over DVB-H System - is a three-year project which started in January 2008. The project is partly funded by the European Union 7th RTD Framework Programme in the context of the Information & Communication Technology (ICT) Cooperation Theme.

The main objective of MOBILE3DTV is to demonstrate the viability of the new technology of mobile 3DTV. The project develops a technology demonstration system for the creation and coding of 3D video content, its delivery over DVB-H and display on a mobile device, equipped with an auto-stereoscopic display.

The MOBILE3DTV consortium is formed by three universities, a public research institute and two SMEs from Finland, Germany, Turkey, and Bulgaria. Partners span diverse yet complementary expertise in the areas of 3D content creation and coding, error resilient transmission, user studies, visual quality enhancement and project management.

For further information about the project, please visit www.mobile3dtv.eu.