Analysis and Design of Unified Hardware Abstraction Layer To Support Various Multimedia SoC with Android Platform[†]

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Abstract

As the significant role of the software platform in the smart phone is now propagating beyond the mobile industry, the software platform is evolving to provide unified multi-screen service facilities over different types of devices such as digital TV and Set-Top Box (STB). However, the application-specific hardware architectures impose difficulties for providing unified software platform for heterogeneous devices. This paper analyzes the differences between mobile and TV/STB System-On-Chip (SoC) architecture and proposes a unified hardware abstraction layer (HAL) to support integration of the software platform on different devices. For the evaluation and demonstration of the proposed design, the unified HAL is applied to the mobile Android platform to implement multi-screen services.

Keywords: *Multi-Screen, System On Chip, Hardware Abstraction Layer, Software Platform, Multimedia, Digital TV, Set-Top Box*

1. Introduction

Traditionally, embedded systems had unique software requirements to implement specific functions under hardware and software limitations. Nevertheless, the embedded consumer electronics devices are becoming generic purpose computing platform which provides various interactive services. The emergence of mobile smart phone is a good example for such trends. Because the software capability became the most important factor of embedded systems, the software platform plays significant role as it provides well-defined APIs and services for various applications. And as the processing multimedia contents grows to be a major application of a software platform, it is the goal of next generation software platform to seamlessly support different types of interactive multimedia consumer devices such as mobile phone/pad, digital TV and Set-Top Box which have different types of screen display. However, the inherent difference of the hardware architecture between mobile devices and TV/STB make it difficult to integrate unified software platform over heterogeneous devices. In this paper, the architectural and functional differences between mobile and TV/STB system-on-chip (SoC) hardware are identified and a unified hardware abstraction layer model which overcomes such dependencies is proposed.

2. Related Works and Analysis Methods

There had been various research and development efforts about the architecture of embedded multimedia systems. The study for integrating different middleware standards and specifications can be found in Song [1] and Hong [2]. For the understanding of the hardware

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perspectives for the multimedia processing, Chen [3] provides an overview of SoC design. And Dajsuren [4] provides common patterns used in the multimedia software frameworks. The current technical status and trends of mobile software platform can be referenced from Butler [5] and Park [6] provides insights about multimedia broadcasting technologies. The application of mobile Android platform for home network and media playback can be referenced from Choi [7] and Hwang [8], respectively.

In this paper, to identify key factors for the design of unified hardware abstraction layer model for both mobile and TV/STB SoC, different hardware architectures are compared by defining a generic multimedia processing model. Throughout the comparative analysis phase, the boundary between hardware and software configurations is identified. For the evaluation and demonstration of the proposed model, Google's mobile Android platform is analyzed and extended to incorporate the unified HAL to support multi-screen service.

3. Designing Generic Software Architecture for Mobile and STB/TV SoC

In this section, the differences between mobile and TV/STB SoC are examined by comparing the supported media processing functionalities and architecture against generic media pipeline processing model.

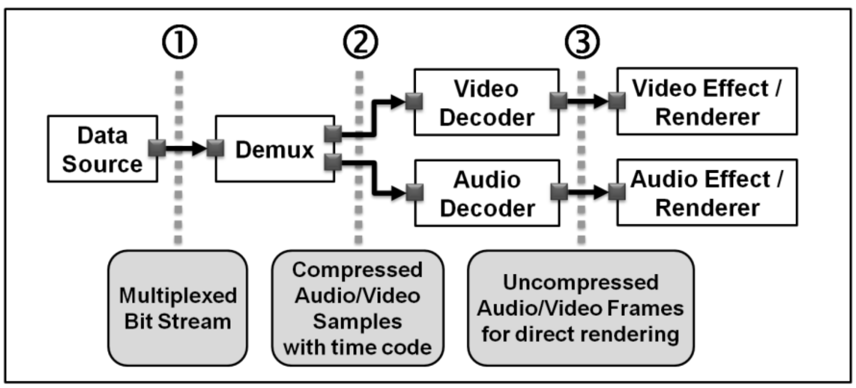

Figure 1. Generic Multimedia Processing Pipeline Model

3.1. Generic Multimedia Processing Model

Just like 3D graphics pipeline model, a graph-based pipeline processing model can be used to represent generic multimedia processing frameworks. The component-based, source-sync relationship can be defined as figure 1. The source component provides data stream to sync component and the sync component delivers processed data along the pipeline to another component. Within multimedia SoC, one or more of these multimedia processing components are implemented as built-in hardware block.

3.2. Comparison of Mobile and TV/STB SoC Architecture and Functions

3.2.1 Mobile SoC Architecture and Functions: The primary functionality of the mobile system was to provide voice/data communication functionality over wireless network. Therefore, the mobile SoC was an auxiliary application processor to the radio interface processor (modem). However, now it has the central role for running software platform in smart phones. The mobile SoC has built-in hardware media codes for decoding and encoding of media data and has 2D/3D graphics hardware modules to accelerate graphics applications.

The user manual of Samsung Electronic's Exynos 4210 mobile processor [9] provides the overall architecture and functionality of modern mobile SoC. To be optimized for mobile multimedia communication over WiFi and 3G networking, the mobile SoC has limited hardware support for frontend interfaces such as digital tuners. Therefore, the implementation of data source and demux processing component depends on the software and the de-multiplexed data stream is fed-up to hardware audio/video decoder. And uncompressed video frames need to be rendered into a graphics buffer (or surface) because frame buffer based single plane blending model is used in general.

3.2.2 Digital TV/STB SoC Architecture and Functions: The main function of digital TV/STB SoC is to process continuous multimedia stream from various sources including digital broadcasting network and stored files. There are hardware inter-connection paths which deliver the bit stream from front-end to demultiplex and from demultiplex to audio / video codecs to form an efficient and seamless media procesing pipeline. To support access to scrambled multimedia contents, descrambling hardware is integral part of the demultiplexor. And becase it supports multi-plane rendering model, output from the video codecs are directly delivered to video scaler / compositor to do alpha blending with graphics plane as part of hardware-based real-time processing. The various kind of audio / video output port support is typical characteristics of TV/STB SoC.

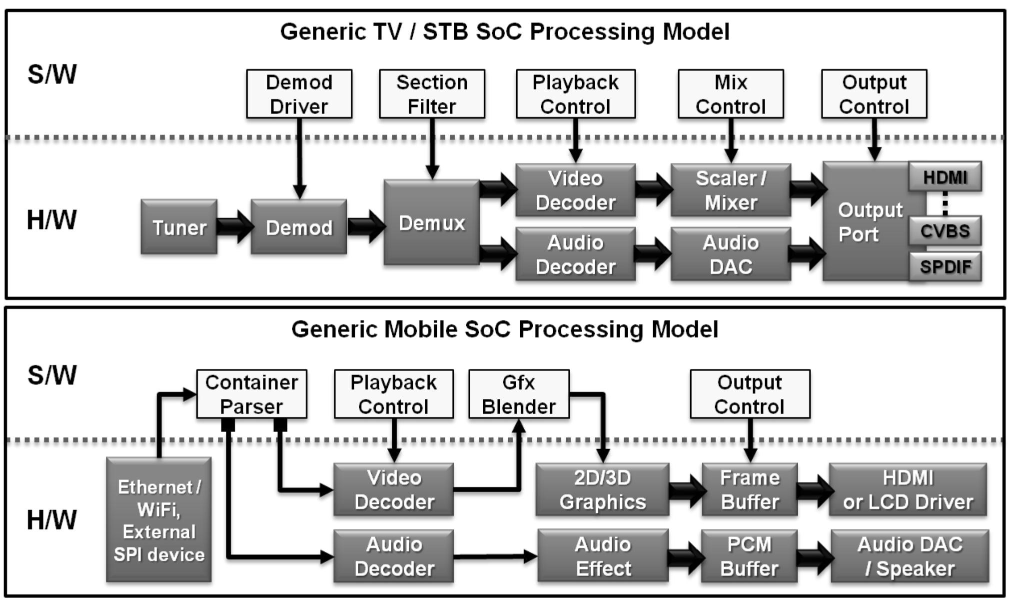

Figure 2. Comparison of Media Processing Model between TV/STB and Mobile SoC

3.3. Core Differences between Mobile and TV/STB SoC: By comparing mobile and TV/STB SoC architectures, three major differences can be identified. First one is the capability of frontend interface for multimedia stream processing and the second is the data stream delivery model and the last one is the method of audio-video rendering including output port support. For frontends, the TV/STB SoC has integral hardware support for various frontend devices such as tuner and demodulator for digital satellite or cable broadcasting network. However, the mobile SoC does not have full-featured hardware interface for frontend processing. The frontend needs to be implemented as data source software model which retrieves the media stream from the network or file system. For the data stream delivery, the TV/STB SoC has hardware demultiplexor which has internal descrambler logic and it delivers the data directly to decoder hardware blocks. For the mobile SoC, demultiplexing is normally done in software by implementing container parser and this software module feed the stream data to Audio/Video hardware decoder. For the method of rendering and output port support, the TV/STB SoC assumes multi-plane rendering model which consists of independent video, graphics, and cursor plane in hardware. At runtime, these separate hardware planes are scaled and alpha-blended by using hardware scaler/mixer. Therefore with minimum software intervention and without consuming CPU processing power, the video can be rendered on output port such as HDMI or component. However, most mobile SoCs normally have single plane rendering model for rendering and the decoded video frame needs to be copied into graphics surface and the 2D processor renders the surface onto frame buffer for final output. Figure 2 provides the result of comparative analysis between mobile and TV/STC SoC.

4. Design and Implementation of the Unified Hardware Abstraction Layer for Mobile Android Platform

Google' mobile Android is one of the prominent software platforms for mobile smart devices. It has replaced existing heterogeneous, incompatible software configurations with unified, interoperable software infrastructure. Because of the general, well-defined interface of Android, there were many attempts to apply the Android on various target devices. However, because of the inherent differences of SoC for diverse target devices, such extensions made incompatible fragmentations of the Android platform among different devices.

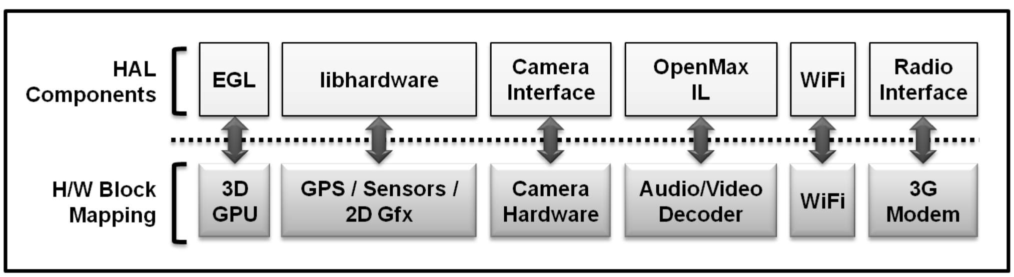

Figure 3. Hardware Abstraction Layer of Mobile Android

4.1. Android Mobile Hardware Abstraction Layer

To provide generic interface to common hardware components used in mobile devices, Android has defined internal mobile hardware abstraction layer (HAL). There are major hardware interface as seen in the figure 3: 3D GPU (EGL for OpenGL ES), GPS/Sensors/2D Graphics (libhardware interface), Camera, Audio/Video Decoders (OpenMax IL), WiFi and 3G Modem (Radio Interface). As the existing hardware abstraction layer of Android is limited to the support of mobile SoC components and does not include features for other multi-screen devices such as digital TV and Set-Top Box, the layer shall be re-structured according to the generic model developed during the analysis of mobile and TV/STB SoC architecture in section 3.3.

4.2. Extending Android HAL Design for Multi-Screen Service

To support different SoC hardware while providing identical level of compatibility to all the Android's system services and applications, a unified hardware abstraction layer model designed as an extension to the core structure of Android HAL according to the result of analysis in section 3. To accommodate different combination of hardware and software functions, the existing mobile Android HAL was built on top of the unified HAL interface as depicted in figure 4. The underlying configuration of hardware and software is transparent to the services and applications of mobile Android platform and the actual combination of hardware and software functionalities can be determined by the SoC-specific HAL implementation.

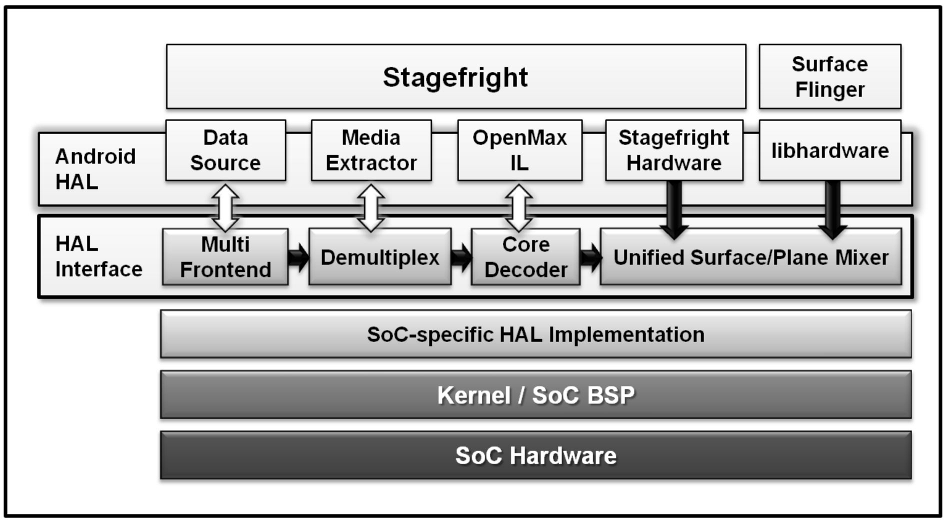

Figure 4. Application of Unified HAL for Android

5. Conclusion and Future works

Throughout the survey of modern multimedia SoC architecture and functionality, the differences among various SoC was identified and a unified hardware abstraction model which supports multiple SoC types could be established. By applying this model to the underlying hardware interface of the mobile Android platform, it can be extended to build the infrastructure for multi-screen service.

With rapid advancement of smart device technologies, the converged software platform will open up a new arena of noble the research and development.

The software architecture for multi-screen service can be considered at different levels. This paper focused on the low-level hardware and software integration to build a foundation of upper layers. The framework-level and service -level research and development works are expected as follow-up topics.

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