Looking at the design of an internet enabled device for the home using ARM Cortex powered SoCs

Internet Enabled Devices for Your Home

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The Internet is now available to everyone, enabling a variety of use cases from news gathering and content sharing to instant messaging. Such activities are primarily enabled by PCs and smartphones while at home the connected TV is starting to take on this role.

In this article we look at the design of an internet enabled device for the home using ARM Cortex powered SoCs. The Cortex-A8 with NEON is the latest processor from ARM which packs a punch on multimedia performance. A detailed analysis of the performance requirements is presented for a multimedia device, capable of playing several audio and video formats suitable for the multitude of formats available on the Internet.

Connecting to the Internet today is still closely tied to our desktops and portable computers. Even mobile phones, with increasing connectivity, are becoming personal Internet navigation devices, their small form factor and screen sizes make them not always the best route for accessing/sharing videos and photos on the Web.

The TV, however, still dominates in the home, thanks to the appeal of its large screen. With the arrival of picture and video sharing sites like YouTube, Flickr and others, consumers are looking beyond their laptops and smartphones to enjoy content. As these sites become increasingly popular, consumers will look to bring them into the family room where the TV currently dominates. In such a context a Home Internet Device (HID) is needed, acting as an IP set top box, bringing Web content or User Generated Content (UGC) to the living room.

Product Conceptualization and Design

System Requirements

A system built to bring Internet content to a TV at home will need to be capable of handling the following system requirements:

- ***Rich Web Experience on a TV screen:*** The HID will leverage the rich content available on the Web to bring an enhanced Web experience to the home user. The HID will connect to favorite menus such as a video listing on YouTube or subscribing to a feed in Yahoo, Google or CNN. This can open up 'on demand' services with users being able to receive services like their favorite Tweets to their TV.

- ***Home Networking of Media:*** The HID will be able to aggregate and be used as a home server for all media content on the Web, as well as within home. This could mean being able to stream a video from the Web or watch your child performing in a school video, streamed straight to your TV, from your home PC server.

- ***Rich Interactive Gaming:*** Rich interactive gaming with 3D graphics will be on the TV instead of your home PC, enabling a rich user experience through one interface.

• ***Digital Picture Frame:*** HID will act as a Digital Picture Frame (DPF), synchronizing with content on the Web to bring you the latest pictures uploaded by family and friends.

• ***Instant Messaging and Video Communication:*** The HID will also connect to an IP network and act as a video communication device for home connected users, enabling discussions via applications like Skype™ or Windows Messenger™.

Connectivity Requirements

• ***Internet Connectivity:*** Given that the primary requirement of this device is to connect to the Internet and bring web content to TV, the device should have an Ethernet connection. Additionally, wireless connectivity (802.11 a/b/g/n) will be desirable, making the HID wireless enabled.

• ***Interface Connectivity:*** The HID is primarily aimed at playing Internet content on TV, having an interface to a SD/MMC card will enable local playback of content on the device. USB connectivity will add the ability to synchronize content with your mobile or other devices and can also serve as a mass storage device interface.

• ***Display Connectivity:*** Since the key purpose of this device is to bring Internet content to the TV, display connectivity in the form of High Definition Multimedia Interface (HDMI), is a must. Additional connectivity, through component video and S-Video outputs would help maintain compatibility with non-HDMI enabled TVs. Since the display medium will be a TV, no LCD connectivity is envisioned, lowering the overall system cost. TV decoder and encoder chips will be required to make sure that regular NTSC out and S-Video is available, providing the additional ability to record from analog TV or cable sources.

• ***Audio Connectivity:*** Stereo outputs are a minimum requirement for TV. Additional line in connectivity helps in providing stereo recording of TV or cable content. A Microphone is also a useful addition for recording functions.

• ***Remote Control:*** IrDA interface is a requirement, providing remote control access to the device. This will also be the primary interface for entering text inputs for browsing the Internet.

• ***Camera Interface:*** Such an interface will enable video communication through the device. As it is connected to the Internet, live video can be shared during a VoIP-based communication using the camera.

Software Requirements

• ***Media Playback:*** The main objective of this device is to connect to the Internet, bringing Web content, video and music to the home. System requirements therefore need to include a Media player, a streaming client capable of connecting to the Internet. The Streaming Media player needs to be capable of supporting peer-to-peer content distribution such as YouTube, Hulu, or BBC iPlayer. Other content delivery mechanisms will also need to be supported, including codecs and other functions such as Digital Rights Management (DRM) to be able to watch pay-per-view as well as user generated content. Additionally, the Media player should be capable of supporting JPEG playback to provide DPF functionality with all the necessary transitions and effects.

• ***Streaming Server:*** As the HID will also provide home server functionality for devices on the home network, streaming server support would be a useful addition.

• ***Web Content Support:*** As Web support is the primary use for such device, a fully W3C compliant HTML/CSS standalone and embeddable browser is a key requirement. Flash support would make the device a compelling buy and would provide a rich Web experience for the user.

• ***Graphics Support:*** Open GL ES 2.x support will be required to bring games alive, as well as enhance the Web experience on the device. Graphics support will also be required to bring the DPF function alive.

• ***Web support:*** Web browsing support in the form of Web toolkits and support for subscribing to the feeds and/or download and play sites, like peer-to-peer content distribution, would be a key requirement to bring a rich consumer Web experience. JavaScript support in software and, if possible, in hardware, will allow for the seamless delivery of Web applications.

Choosing the Processor Sub System

Given the above system and software requirements, a powerful processor capable of handling the complex software as well as the web requirements is needed. The latest ARM Cortex™ family of processors equipped with vector coprocessors in the form of NEON™ have the power and scalability to handle these complex software requirements. The Cortex family of processors, with their deep pipelines, are capable of clocking higher speeds, making them ideal for handling such demanding applications.

With the increasing popularity of third party software available on ARM processors, and the ease of bringing web applications to ARM processors, the ARM Cortex family of processors are ideal for building these Internet devices on. One of the processor families available in the market suitable for such devices is Texas Instruments' OMAP series of processors, notably the OMAP3515 processor composed of a Cortex-A8 + NEON processor clocked at 600 MHz coupled with a graphics coprocessor in the form of the powerful PowerVR SGXTM core fits the bill well for creating a HID.

Processing power and flexibility: The Cortex-A8 + NEON processor is capable of handling both multimedia and non-multimedia applications. The NEON powered Cortex-A8 processor is capable of decoding video and audio streams.

• *Clock speed of 600 MHz:* it can support most video standards including H.264, MPEG-4, and VC-1 at standard resolution (SD) (720x480 at 30 frames per second, 720x576 at 25 frames per sec-

ond) within 75% loading of the processor; leaving the remaining 25% of the processing power free for other functions such as audio decode and video playback.

• *Additional features:* Aside from the powerful NEON vector processor, the Cortex-A8 core on the OMAP3515 is packed with features such as TrustZone®, designed to secure consumer products, Thumb®-2 for higher performance at lower code density and, Jazelle® RCT execution environment architecture for accelerating Java-based application support.

• *Strong Graphics Capabilities:* Powerful graphics support on the device make UI applications rendering faster and easier, especially with OpenGL ES 1.1 and 2.0 and OpenVG 1.0 support. 16Kbytes of L1 - Instruction Cache and 16Kbytes of L1 - Data cache, with a large 256Kbytes of unified L2 cache, helps speed up performance of all multimedia as well as non-multimedia algorithms. Built-in display subsystem support on the OMAP3515 includes 24-bit RGB output, HD resolution output, Composite NTSC/PAL video support and resizing of output images from factor 1/8- to 4- & 8-bit alpha blending.

• *Broad Connectivity:* A removable media interface, in the form of MMC/SD/SDIO card support, allows for storage of media as required in the system and connectivity requirements listed in sections above. Connectivity requirements envisioned on a HID are satisfied by the Serial and UART connections for remote IrDA including the USB OTG support. Additionally, the device can decode JPEG images, required for the DPF.

• *Eco-friendly system:* The powerful Cortex-A8+NEON core can run one CIF channel encode and decode simultaneously within 400 MHz (of H.263 or MPEG-4 video) to provide video communication features. Comprehensive power reset and clock management help reduce power consumption leading to a 'greener' design. An architecture diagram of the device is shown below in figure 1.

Software Architecture

Given the above OMAP3515 system block diagram and the features available on the device, we now need to build a software architecture which will equip the HID with the necessary software to be able to connect to the Internet and bring Web content to our home TV.

The first step in the software architecture is to evaluate the Operating System (OS) choices. There are several choices for OS that could be considered, but given the proliferation of Linux as a royalty free OS and the availability of Linux ports on devices, it seems an obvious choice. Google Android, for example, already has a strong developer community and is quickly gaining in popularity. It also has the advantage of coming bundled with Google applications and a framework for Media Player.

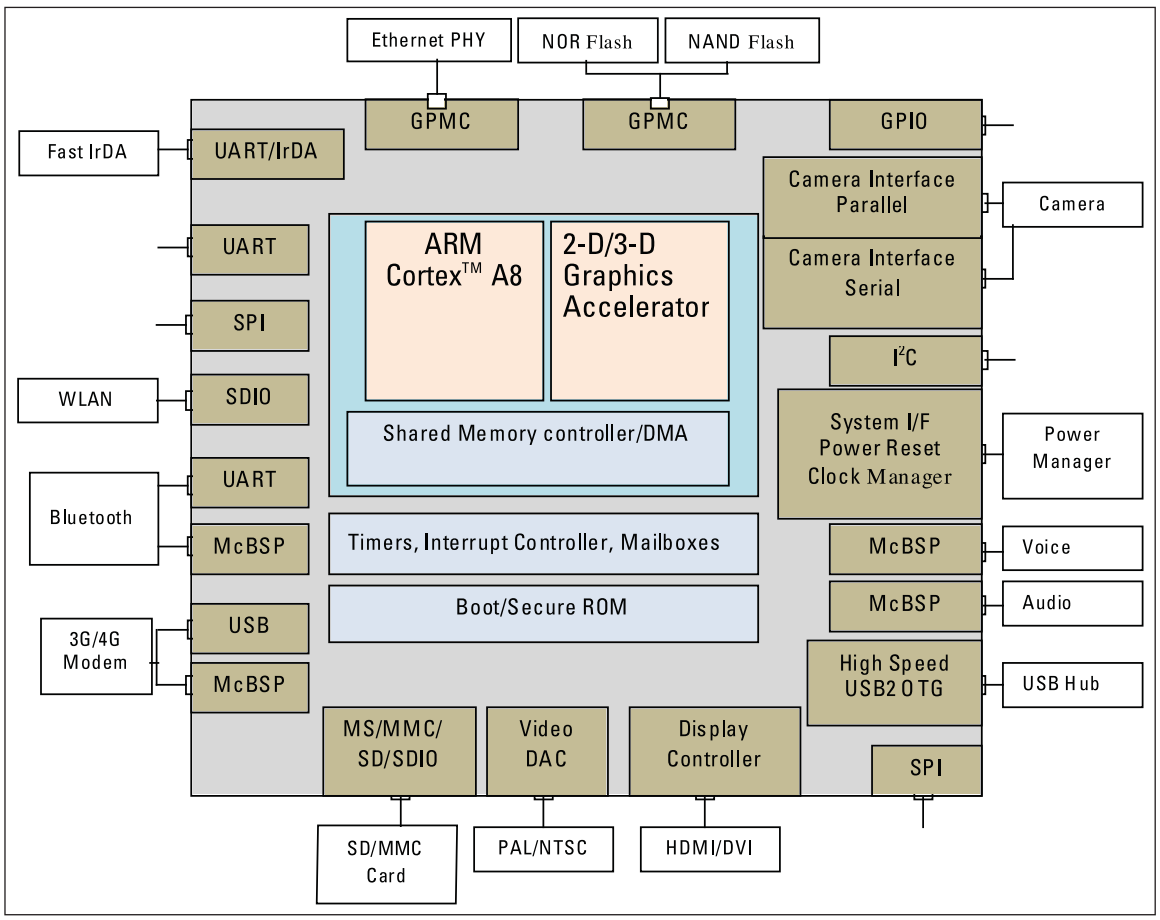

Figure 1: OMAP3515 based HID System Block Diagram

Drivers will need to be supported by the chosen connectivity devices. This includes the video out or frame buffer driver for video display onto the TV through a HDMI/DVI connection or through the NTSC/PAL. In addition, WLAN, WiFi, and Bluetooth drivers will be needed for connectivity as well as USB and MMC/SD card drivers for mass storage support. An image interface and a camera driver will also be required for video communication applications. Other standard embedded support such as bootloader, NOR/NAND flash support are taken as read.

On the middleware side, given the key requirements of bringing YouTube and other internet content to TV, a Multimedia Engine capable of supporting playback of Web content along

with support for other functionalities like video communication, DPF functionality is essential.

Ittiam Media System SDK (MSS) is a proven multimedia engine, bundled with codecs and components. This has been verified on several TI OMAP platforms for different multimedia applications including Portable Media Player & Recorders, Digital Video Recorders, Broadcast delivery, Transcoders, Streaming clients/servers, Digital Media Adapters and Network Media Players. The Ittiam MSS has a well defined set of media Application Programming Interfaces (API) that covers many functions of a multimedia application and also has a strong portfolio of codecs and components including parsers, composers, streaming subsystems, DRM amongst many, and can integrate into several peripherals seamlessly.

This small footprint highly portable MSS is designed for embedded multimedia, ensuring high performance abstraction layers that minimize the porting effort required to move to a new platform. With its SDK type approach it makes the application development and integration to other middleware and application components, like DLNA clients or streaming protocols, simple and easy.

The Media System SDK is also capable of supporting voice and video calls over SIP. Audio and video codecs optimized on the Cortex-A8+NEON, providing the required decoding and encoding capabilities to support any of the above mentioned multimedia applications. These codecs have been optimized for performance to ensure a rich user experience in terms of both frame rates and resolutions in bringing internet content to TV.

Additionally, the device should support software extendibility which will enable software upgrades on the device to support the ever growing demands of the Internet. As shown in figure 2, a software stack built in a layered form helps to tie in all the applications on the device. Highly optimized and efficient codecs and middleware like DRM, file parsers, RTP, RTSP, HTTP subsystems are connected to a framework such as Ittiam's Media System Framework, which supports all multimedia features including playback of audio and video streams either from a file, or through a streaming system like RTP/RTSP based system or a progressive HTTP download. The MSS also supports JPEG display with transitions effects and can also run a simultaneous slide show with audio. Here again the JPEG playback can be from a progressive HTTP download or through a RTP/RTSP system. DRM support in the MSS coupled with Web applications allow users to purchase content online and play it either through download or though a streaming system.

The APIs provided by the MSS can be used across several applications to enable media playback, archival and streaming. MSS can also stream the content from a local server to other devices within the home through the streaming server or act as a home streaming player with the DLNA client application on the device. Adobe-like UI enhancements and other Web applications can be accelerated using the built-in support for Open GL in hardware through well defined Open GL APIs. Additionally, the MSS along with the camera and microphone inputs can be used to drive a video communication application which can be either VoIP based or on a local dedicated home network within an apartment or community complex.

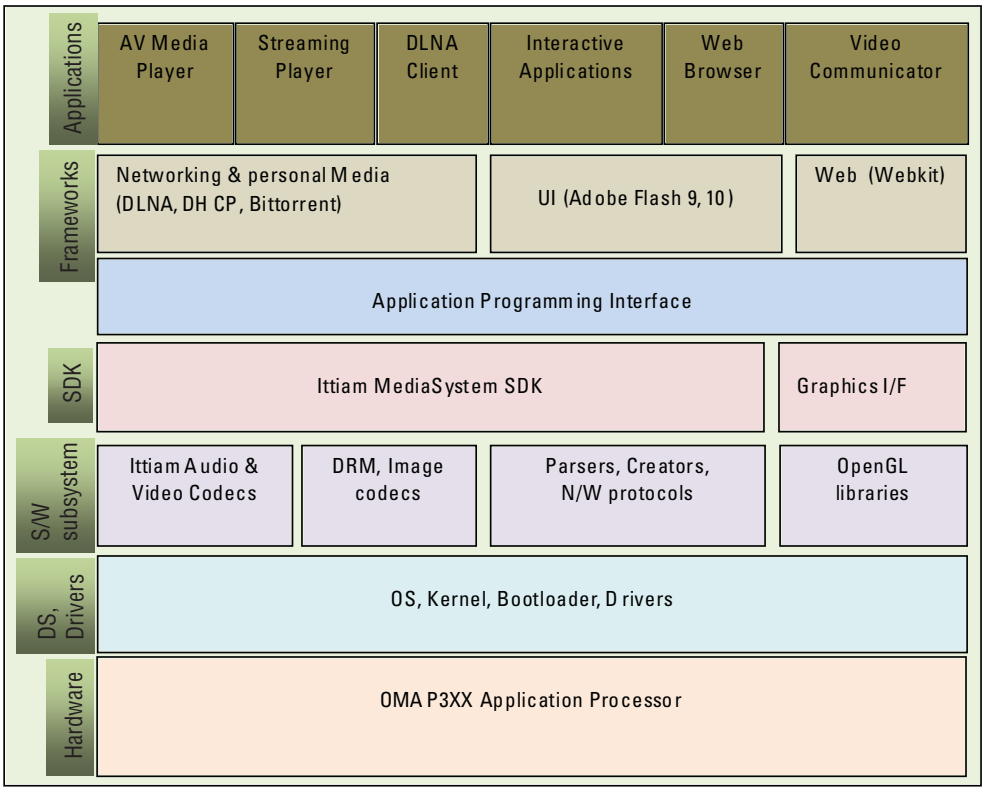

Figure 2: Software Architecture

The ecosystem of the OMAP3515 device, coupled with the ease of programmability for the Cortex-A8 processor core and software system can enable a rich applications canvas for web connected devices.

Conclusions

In this article we have covered the system design of a Home Internet Device which can be used as a companion device to access your favorite content on the Web for the TV. We have presented a complete programmable platform based system and software architecture design. The advantage of this design is that it is simple, yet scalable to handle the ever-changing demands of Internet multimedia. The programmability and power of the Cortex-A8 processor makes the design scalable to handle new media technologies as well as applications overtime.

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