System on Chip Architectures and Modelling 2013

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System Overview

Virtex 6 ML 605

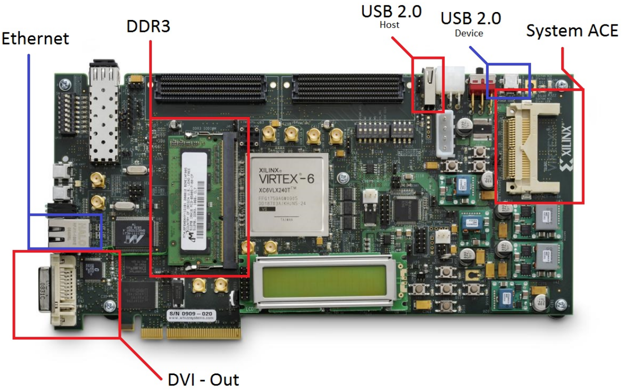


Figure: Xilinx ML605 Evaluation Board[1]

The System

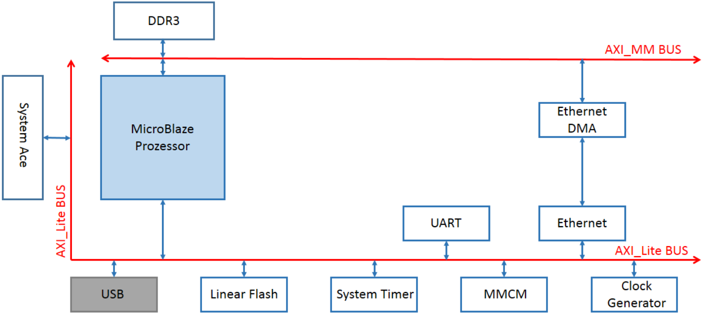


Figure: Block diagram of our system

The System

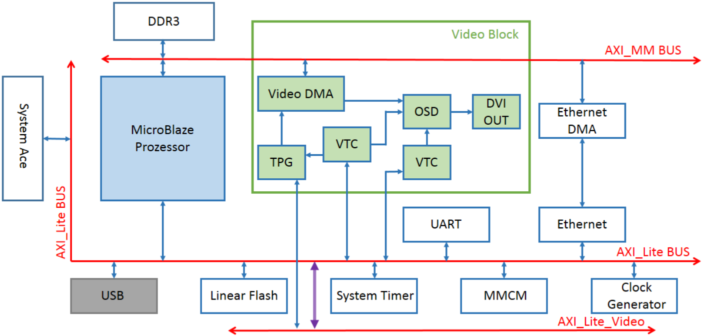


Figure: Block diagram of our system

The Video System

Overview

- For Smart-TV we would need a high performance hardware video system
- Challenging task since various complex IP cores and protocols have to be connected - and understood
- VLC media player as video source writing into framebuffer
- Therefore system must also be capable of running Linux

The Final Hardware System

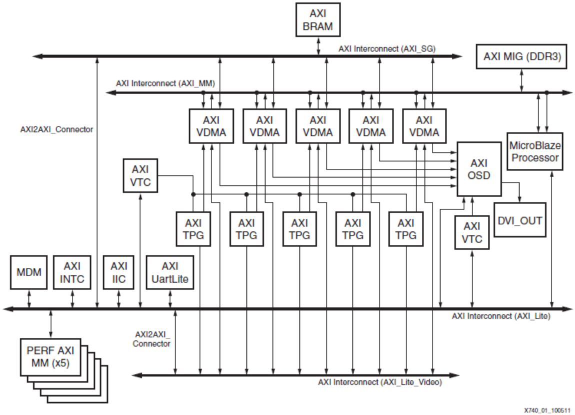


Figure: Our video system based on Xilinx' xapp740[2]

Main Components of HW

- The following Xilinx IP cores have been used:
  - Video Direct Memory Access (VDMA) for video memory movement
  - On Screen Display (OSD) for sending video to DVI output chip (Chrontel) and alpha layering for picture-in-picture
  - Video Timing Controller (for timing generation of images for OSD)
  - DVI Chip Chrontel Ch7301

Challenges

- High performance video system needed for resolutions of up to e.g. 1920x1080@60$frames/sec$
- With 4 bytes per pixel we get a bandwidth requirement of 497.7MB/sec for each pipeline (4Gb/sec)!
- Adaption of 5-stage video pipeline reference example for our needs (very complex system)
- The protocol switch of Xilinx' cores from XSVI to AXI4-Stream protocol (no updated reference designs)
- Control of Chrontel chip via IIC from Linux (without having a driver)

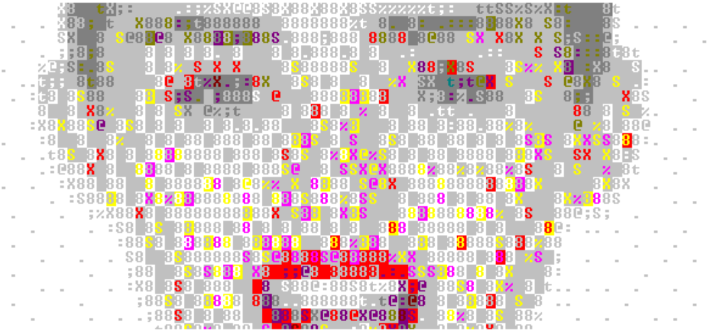
The VLC Player

VLC Player - Why?

- VLC is portable, free and open-source media player
- VLC is very powerfull and provides many functionalities
  - Playing local media (MP3, MPEG, AVI,...)
  - Playing webvideo (youtube.com,...)
  - Playing media stream
  - Stream server
- VLC provides over 200 configuration possibilities
  - Media libraries (libVA, FAAD, MAD,...)
  - Video plugin (XVideo, OpenGL, X11,...)
  - Audio plugin (pulse, alsa, oss,...)
  - Interface plugin (QT, ncurses, lirc,...)
  - Optimization (MMX, SSE, NEON,...)
- $\rightarrow$ Complex configuration and make framework

VLC Player - Example

VLC Player - Example



VLC Player - XCompilation for MicroBlaze

- Find minimal configuration for minimal dependencies
- Use PetaLinux for cross compilation
- Use output from *make* to generate compiling script:
  - Replace basic compiling commands:

nm → microblazeel-xilinx-linux-gnu-nm
ar → microblazeel-xilinx-linux-gnu-ar

ranlib → microblazeel-xilinx-linux-gnu-ranlib

VLC Player - XCompilation for MicroBlaze

- Find minimal configuration for minimal dependencies
- Use PetaLinux for cross compilation
- Use output from *make* to generate compiling script:
  - Replace basic compiling commands
  - Replace *doltcompile gcc*:

doltcompile gcc module.c -o module.lo $\rightarrow$
microblazeel-xilinx-linux-gnu-gcc module.c -fPIC -DPIC -o module.lo
microblazeel-xilinx-linux-gnu-gcc module.c -fPIC -DPIC -o .libs/module.o module.c
microblazeel-xilinx-linux-gnu-gcc module.c -o module.o >/dev/null 2 >&1

VLC Player - XCompilation for MicroBlaze

- Find minimal configuration for minimal dependencies
- Use PetaLinux for cross compilation
- Use output from *make* to generate compiling script:
  - Replace basic compiling commands
  - Replace *doltcompile gcc*
  - Replace *doltlibtool*:

libtool: link: ranlib .libs/libvlc_srtp.a →

microblazeel-xilinx-linux-gnu-ranlib .libs/libvlc_srtp.a

VLC Player - XCompilation for MicroBlaze

- Find minimal configuration for minimal dependencies
- Use PetaLinux for cross compilation
- Use output from *make* to generate compiling script:
  - Replace basic compiling commands
  - Replace *doltcompile gcc*
  - Replace *doltlibtool*
  - Replace unsopported flags (-pedantic, -funroll-loops, ...)
  - make all .libs directories needed for modules
  - add additional compiling flags

VLC Player - External Libraries

- VLC player needs external libraries for codec,...
  - zlib
  - libVA
  - ncurses
  - libcaca
  - libpng
- Same procedure as for VLC source code to compile

Compact Flash Card and Video Decoder

Compact Flash Card File System

- 2GB Compact Flash Card
- 256 MB EXT3 Partition
- FAT16 Partition
- Up to 8 images can be stored
- Configuration with address switch
- First Partition FAT16
- "xilinx.sys" in root
- Format: DOS 8.3
- Max. 16 directories/files allowed

```
root@Final-HW-2-DevTreeGentrd-0:/media/CF_FAT# cd xilinx/
root@Final-HW-2-DevTreeGentrd-0:/media/CF_FAT/xilinx# ls -l
drwxr-xr-x    2 root     root         32768 Dec  4  2013 cfg0
drwxr-xr-x    2 root     root         32768 Dec  9  2013 cfg1
drwxr-xr-x    2 root     root         32768 Dec  9  2013 cfg2
drwxr-xr-x    2 root     root         32768 Dec  8  2013 cfg3
drwxr-xr-x    2 root     root         32768 Dec  9  2013 cfg4
drwxr-xr-x    2 root     root         32768 Dec  9  2013 cfg5
drwxr-xr-x    3 root     root         32768 Dec  6  2013 cfg6
drwxr-xr-x    2 root     root         32768 Dec  4  2013 cfg7
root@Final-HW-2-DevTreeGentrd-0:/media/CF_FAT/xilinx#
```

Compact Flash Card

- Connected on AXI-Lite
- Communication with Microblaze
- Clock: 33 MHz
- Xilinx System ACE Controller
  - Boot from CF Card
  - Mount CF Card to PetaLinux
- VLC source files stored on CF
- Remove safely
  - Non-operating state

[a]

[a] Reference: CF Card Image

Video Decoder

- OpenCores Platform Open Source Hardware IP Cores
  - Nova H.264/AVC Baseline Decoder
  - NPI Graphics Controller
- McMaster University, Ontario, Canada
  - Ethernet - MPEG2 Decoder
- Xilinx Cores
  - Xilinx MPEG-2 Decoder
  - Xilinx H.264 Decoder
  - Premium License
- Software solution
  - VLC as decoding unit

System Integration

System Integration

- Which processor?
- Leon3
  - Too complex
  - No bus interface in XPS! (bus wrappers?)
  - Snapdragon
- Microblaze
  - Fulfills our needs
  - Toolchain with PetaLinux!
  - Prebuild images
  - Configuration wizard in XPS

System Integration - Microblaze

- Xilinx
- Exists only as softcore!
- 32 Bit RISC microcontroller
- AXI/PLB interface
- Access to local memory over LMB bus
  - Reduces loading on the other buses
- MMU
- Performance optimized version
  - Execution pipeline expanded to 5-stages
  - Top speeds of 210 MHz

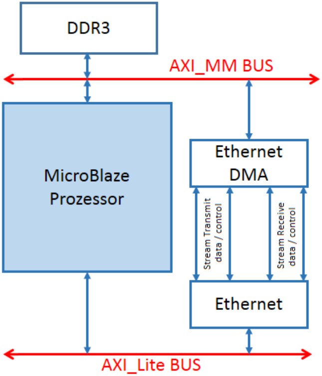
System Integration

- Started working with PetaLinux toolchain
- First tests with JTAG
- Later on, SystemACE file (CF card)
- Problems with XPS versions
- Lots of work to get video output running
  - Xilinx reference design
  - Test and integrate it into our own design
- Build own userspace software to control the DVI core
- Tweak design to get Ethernet running (new clock)

Peripherals

Ethernet

- The following two IP cores have been used
  - AXI Ethernet v3.01.a
  - AXI DMA v6.03.a
- Ethernet
  - Core is for Ethernet connection
  - Transmit & receive data through stream interface
- Direct Memory Access (DMA)
  - Core is for Direct Memory Access
  - Connected with Ethernet over stream interface
  - Connected with DDR3 memory over AXI_MM



Camera

- We used a Logitech Webcam C300
- Possible use of the camera
  - Streaming of video into network
  - Face detection of user
- Integration in Linux with USB Video Class driver's
- USB is not supported in our system

USB Controller

- Board provides USB support via Cypress controller (CY7C67300)
- The mainly used IP cores are
  - XPS External Peripheral Controller with PLB Bus interface
    - Discarded because of AXI use
  - AXI USB2.0 for direct connectivity with USB
    - Could not be made to run in the system
  - AXI External Peripheral Controller with AXI Bus interface
    - Has not been tested with our hardware
- Possibilities why USB is not working
  - Not working with our hardware
  - Wrong hardware connections
  - Errors during kernel configuration with PetaLinux

Linux

PetaLinux

- Provided by Xilinx (original vendor PetaLogix)
- Commercial Linux distribution - free for evaluation (1 year)
- Kernel version 2.6.x
- Plug-In for Xilinx Software Development Kit
- Based on BoardSupportPackages
- Easy integration of user programs and libraries
- Toolchain for crosscompilation and linking

WorkFlow

- Create hardware in XPS
- Export result as bit-file and system description as XML
- Import hardware system as BSP into SDK
- Configure Linux via GUI
- Build and download to board or test with QEMU

SystemAce

- FPGA configuration and software loading from CF
- Needed files:
  - Bitstream (system.bit)
  - Software image (image.elf)
  - SystemAce generator script (genace.tcl)
- Packed together with xmd
- *xmd -tcl genace.tcl -hw system.bit -elf image.elf -ace linuxmb.ace -board ml605 -target mdm*
- *linuxmb.ace* file copied on CF
- SystemAce controller extracts bitstream to configure FPGA
- Loads software image and sets PC

PetaLinux Kernel Configuration

PetaLinux Kernel Configuration

- The Linux kernel could be defined as the ”heart” of our operating system
- It attends that the HW and SW of our design work right together
- Its main functions are managing:
  - The memory of all the programs and process in progress
  - The processor time that the programs and process in progress use
  - The access to all the peripherals/elements of our design

PetaLinux Kernel Configuration

- With the PetaLinux SDK and the Xilinx ISE we find a friendly GUI for configuring the Kernel
- We will launch the Linux kernel configuration menu and configure it to meet our requirements.
- After saving, and building the Kernel we will have a file with which boot PetaLinux in our FPGA.

[a]

[a] Reference: Kernel configuration using PetaLinux SDK

PetaLinux Kernel Configuration

- For each HW that we developed we configured in the kernel:
  - Ethernet: autoconfiguration + DHCP, Core Driver
  - Filesystem: ext3, fat support, Native Language support: cp437, ASCII, UTF-8, NLS ISO 8859-1 (Latin-1)
  - Application/System Configuration: password was set empty.

...and finally

Smart TV

S.M.A.R.T. T.V.

Speech **M**edia **A**ssistant for **R**eal **T**echnicians - **T**ough **V**ersion

Thank you for your attention!

References

[1] - http://press.xilinx.com/index.php?s=20291&mode=gallery&cat=2764
[2] - http://www.xilinx.com/support/documentation/application_notes/xapp740_axi_video.pdf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