System on Chip 2011
Alarming System
Introduction

Alarming System

- Motion detection
- Sound detection
- Encrypted transmission of captured video
- Display of video
- Notification in case of an alarm
System Overview
Equipment

- Virtex®-6 FPGA ML605
- Xilinx tools
- Leon3
- MicroBlaze
- Various open-source IP cores
Groups

Group 1
- Video Team
- Audio Team
- Linux Team 1
- Network Team

Group 2
- Graphic Team
- Alarming Team
- Linux Team 2
- Crypto Team
VIDEO - TEAM
Motion Detection

Object                Image                  Filtered and scaled

Motion       Diff. + Threshold       Result

Motion               Diff. + Threshold               Result
Video Team Data Flow

Camera

YUYV

YUYV to RGB

RGB

Enable

Colorize

Processed Frame

Motion Detection

Threshold

Motion Level

Downsample

Counter

GRAY
Video Processing Unit
Detection Board Overview

Logitech C300 UVC compliant

TCP

V4L2 mmap()

Linux

MoDeSt Binary

mmap()

Virtex 6

Microblaze

Video Processing Unit

IPIF

Alarming Board

DDR

Memory Interf.

Audio Detection

Crypto Core

Preamplifier

Microphone
AUDIO - TEAM
Task

- Sound detector
  - soundlevel reaches threshold
  - → trigger an alarm signal
SoundDetector – Basic Components

- External hardware
  - Microphone, microphone preamplifier

- Analog to digital converter
  - Virtex 6 System Monitor
  - 10-bit resolution, up to 200k samples/second

- Sound detector
  - Digital audio samples
  - Average filter
  - Comparator to trigger an alarm
Integration

- Sound detector connected to MicroBlaze
- Communication via AXI4-lite bus
- Alarm signal and average value stored in register
- Software features
  - Reset sound detector
  - Set new threshold
- Send alarm signal and average value to the second board
LINUX TEAM 1
Objectives

- Get familiar with AMBER project
  - ARM core from opencores
  - Inspect inner workings

- Synthesize AMBER

- Get linux running on AMBER

- Assist other teams in Linux issues
Obstacles

- AMBER
  - No RAM bridge
  - Documentation
  - No debugging facilities

- Backup solution
  - Xilinx microblaze CPU
USB

- USB
  - Not supported within Xilinx kernel
  - Interfacing the USB chip
  - Xilinx USB demo

- Backup solution
  - USB IP
  - Stream RAW video
NETWORK - TEAM
Network Team

Ethernet Connection
Network Team

LogiCORE IP Virtex-6 FPGA Embedded Tri-Mode Ethernet MAC

(ug800_v6_emac.pdf)
Network Team

- Tutorial custom IP-core integration & access
- Support of Linux Team 1
- USB support – EPC-core integration – Cypress
- Template how to access registers from userspace
- Integration of IP cores from other teams
CRYPTO - TEAM
AES CryptoCore

- OpenCores
  - AES in ECB mode
  - 128-bit keysize

- Specification
  - 500 slices
  - 32-bit port width
  - Keyexpansion 83 clock cycles
  - Encryption / decryption 11 clock cycles
System View

Detection Board
- Encrypt
- Send via TCP/IP

Alarming Board
- Receive
- Decrypt
Integration

- **MicroBlaze**
  - Advanced eXtensible Interface (AXI) 4 Lite
  - \( f_{\text{max, Simulation}} = 188.4 \text{ MHz} \)
  - Software integration
  - MMIO using kernel driver

- **LEON 3**
  - Advanced Peripheral Bus (APB)
  - \( f_{\text{max, Leon}} = 174 \text{ MHz} \)
  - Software integration
  - MMIO using kernel driver
GRAPHICS - TEAM
Alarming Board Overview
Chrontel CH7301C DVI Transmitter

- Supporting graphics resolutions up to 1600x1200 pixels
- Up to 165M pixel/second
- Low jitter PLL for generation of the high frequency clock
- Convert digital data input to a DVI output
- Modes of operation:
  - RGB Bypass
  - DVI Output
- Configuration over I2C
SVGA IP Core

- Developed by Gaisler Aeroflex
- Pixel based video controller
- Supports custom resolution with variable bit depth and refresh rates
- Uses external frame buffer in AHB address space
- Digital graphic interface for communication with DVI transmitter
- HSYNC, VSYNC signals for DVI control
- Video driver for the core is provided for Snapgear Linux
ALARMING - TEAM
LCD

- Hardware IP module
- Integration in Leon3
- Software control via driver
- Userprogram for Linux
- Menu
GSM

- Phone call
- SMS
- GSM capable mobilephone
- UART interface
- AT command
Sound and LEDs

- External circuits
- Buzzer
  - controlled by IO pin
- LEDs
  - controlled by IO pin
LINUX TEAM 2
Leon3

- 32-bit SPARC V8 instruction set
- 7-stage pipeline (1.4 DMIPS/MHz)
- MMU included
- Hardware multiply and divide
- FPU (single and double precision)
- Amba 2.0 bus interface
Snapgear Linux

- Kernel 2.6.21.1
- MMU support
- Leon glibc cross compiler
- Interrupts and addresses not accessible from user space → kernel drivers
Software

Flow control:

- Establish connection with board 1
- Send data to crypto core
- Write encrypted data in the frame buffer
- Parameter configuration over LCD
- If alarm, start call

- Encrypt / Decrypt
- Write to frame buffer
- LCD configuration and control
- Start a call and send a message
Conclusion

- Open does not mean easy
- Debugging
- Hardware support
Thanks for your attention!
Live Demonstration!
References

http://opencores.org
http://v4l2spec.bytesex.org/spec/