Further Experiences Teaching an FPGA-based Embedded Systems Class

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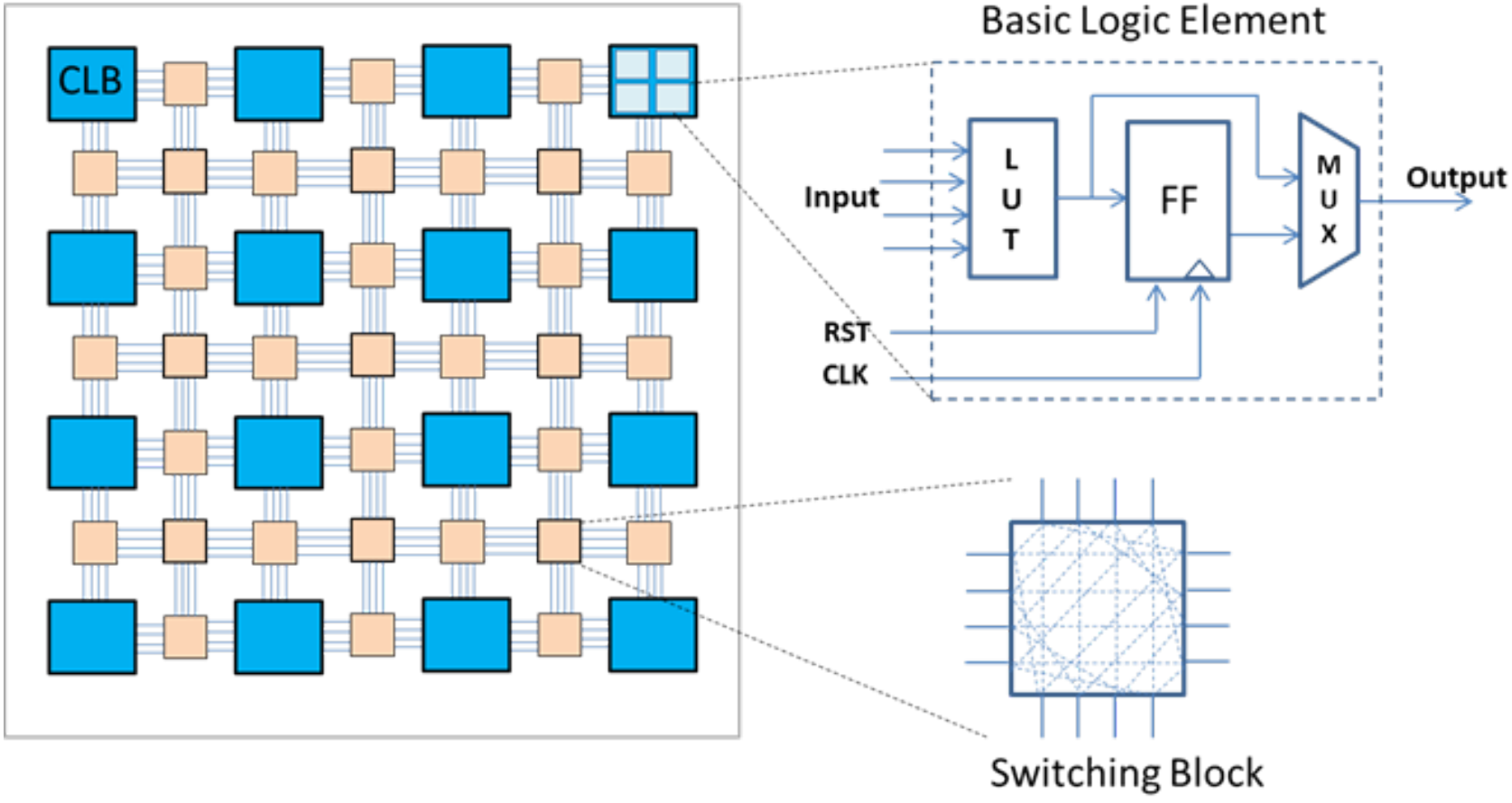
What is an FPGA?

A Field Programmble Gate Array:
A configurable circuit; not a stored-program computer



LUT: 16-element lookup table

Source: http://evergreen.loyola.edu/dhhoe/www/HoeResearchFPGA.htm

Why FPGAs?

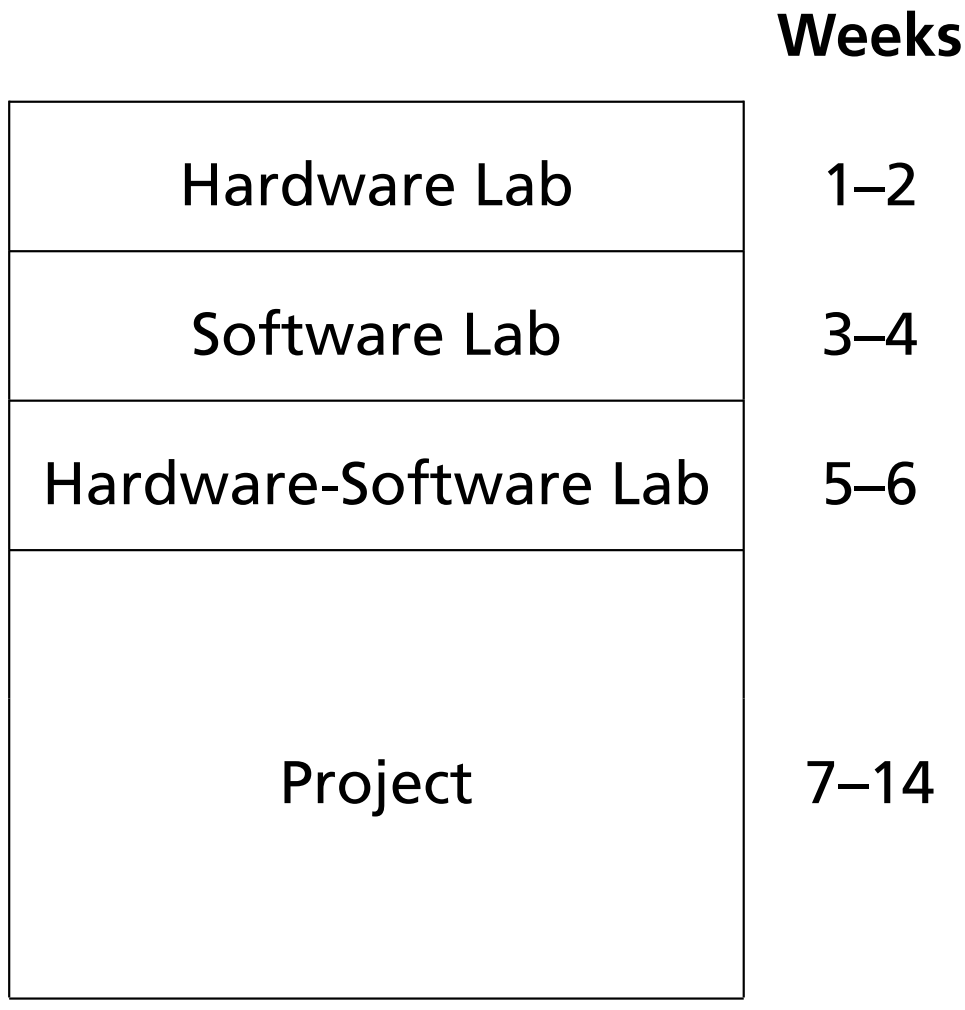
Students can explore hardware/software boundary

Easy to put a stored-program computer on an FPGA

Easy to add custom peripherals

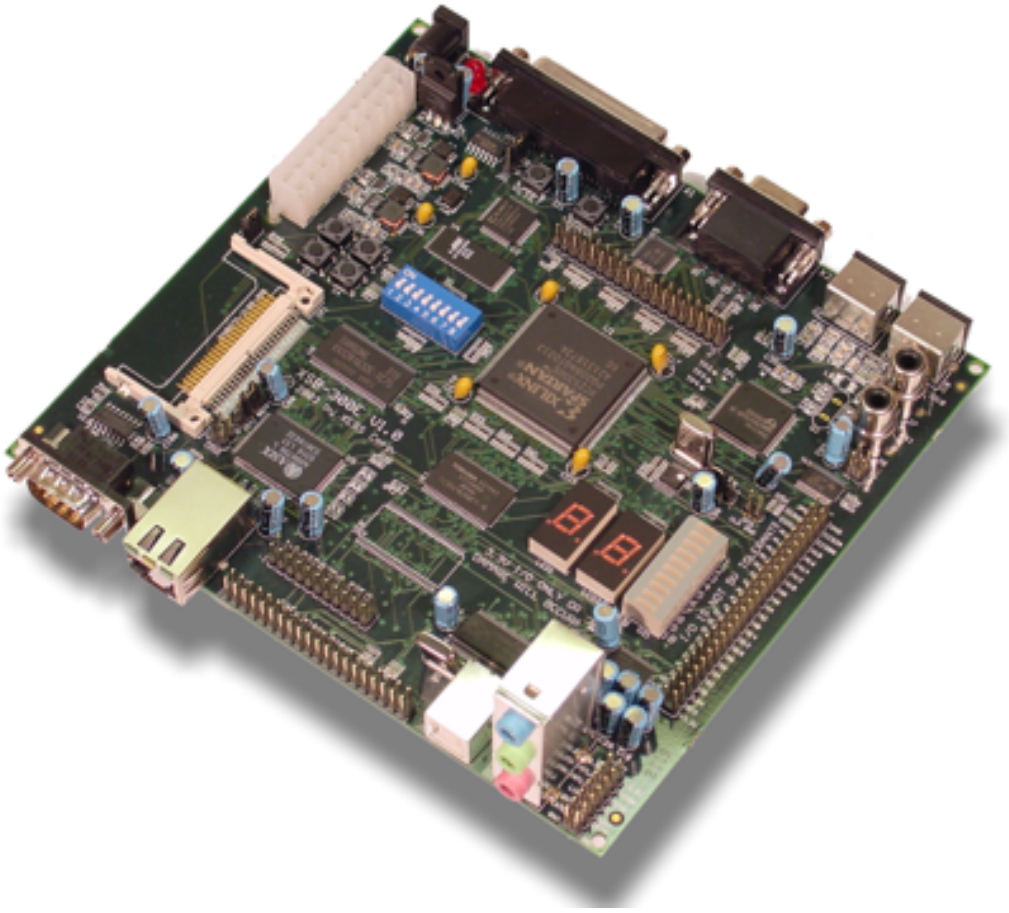
FPGA	**Single-Board Computer**
Flexible	Cheaper
Custom peripherals	Stock peripherals
Commercially uncommon	Mainstream
Digital logic design w/o soldering	Software-only
Demands very wide range of skills	More narrow

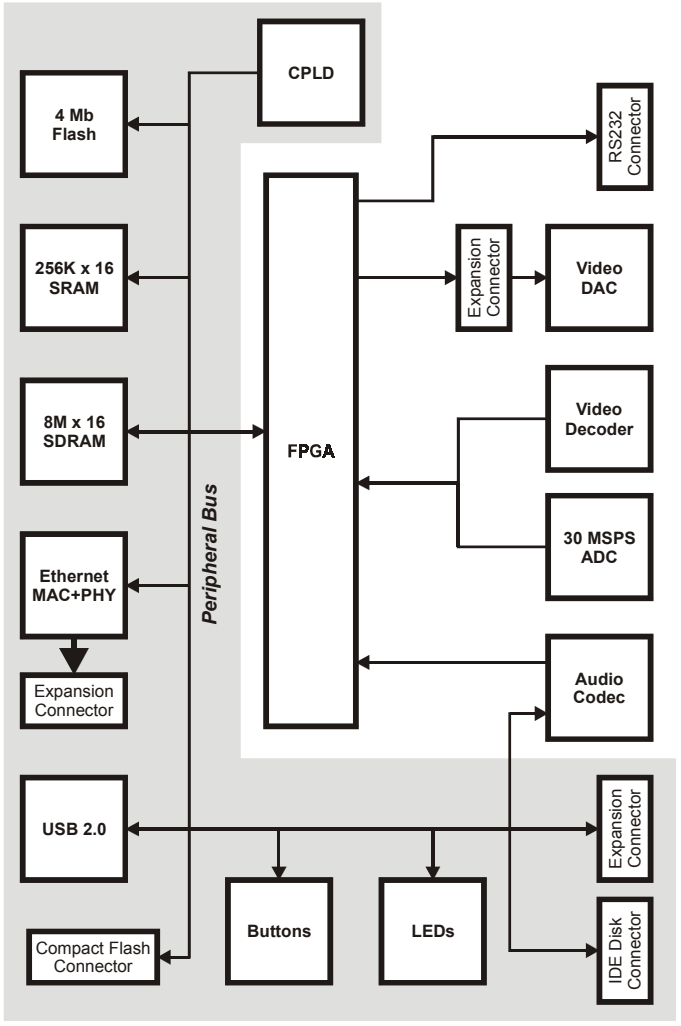
Basic Class Structure



Labs come with skeletons; Lab 3 typical project skeleton

2003–2006: XESS XSB-300E (Xilinx Spartan IIE)





2003–2006: XESS XSB-300E (Xilinx Spartan IIE)

Microblaze soft processor

Plenty of peripherals:
VGA, video in, audio I/O, Ethernet, USB, PS/2, SRAM, DRAM, Flash

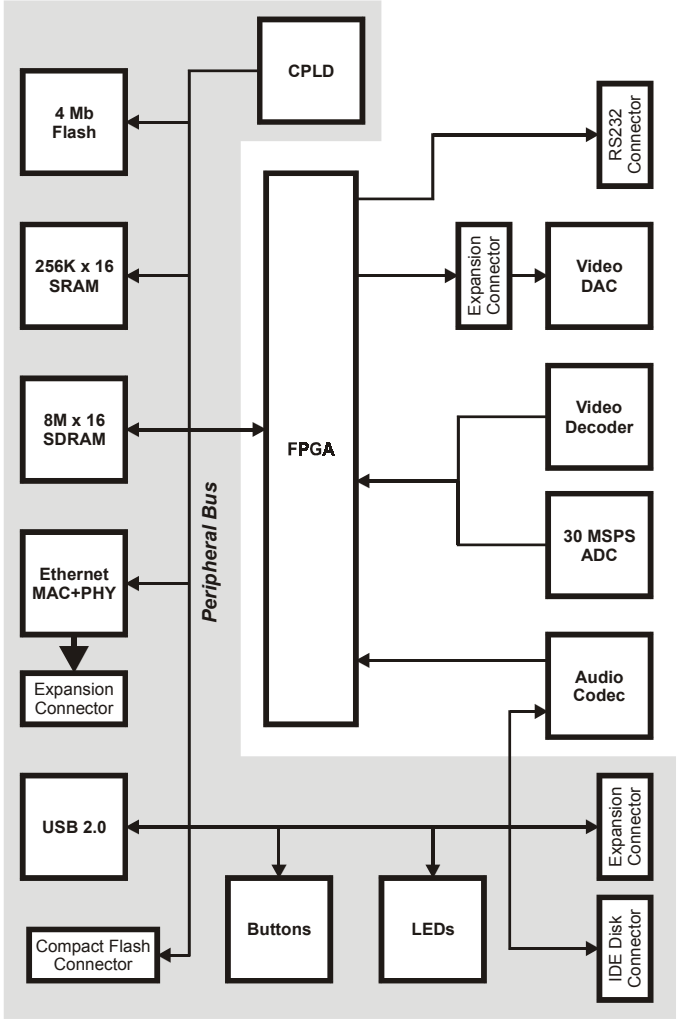
Pin limit forced bussed peripherals

Hard to use more than one

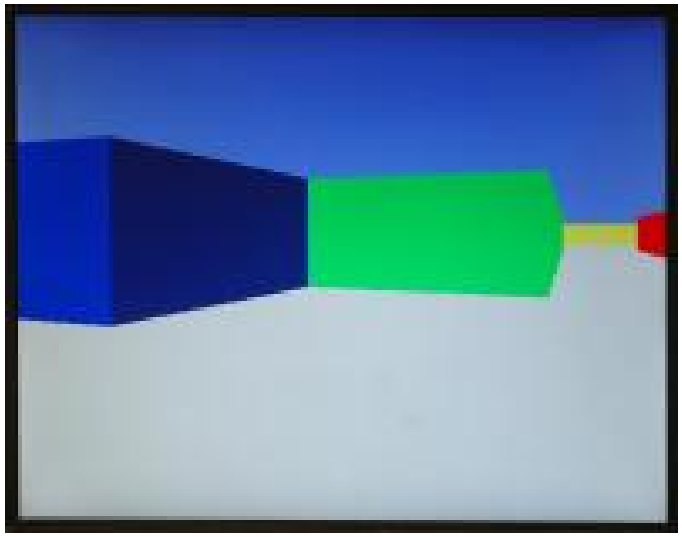
SRAM usually needed; never enough FPGA RAM

Used VHDL

[Edwards, WESE 2005]

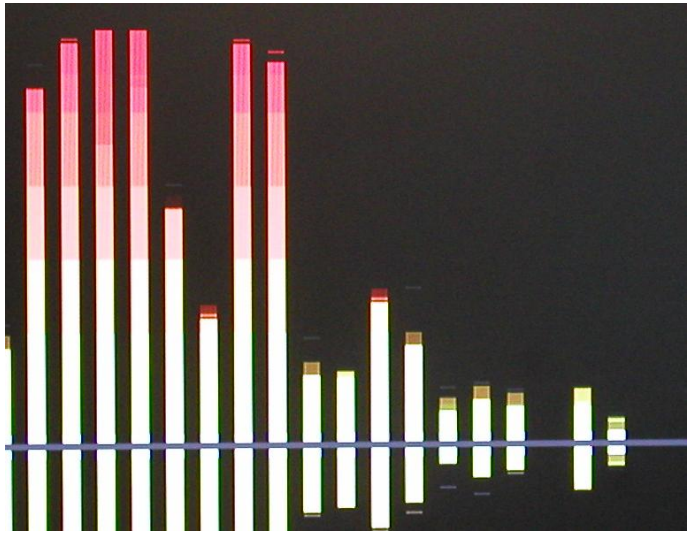


XSB Projects



Raycasting game

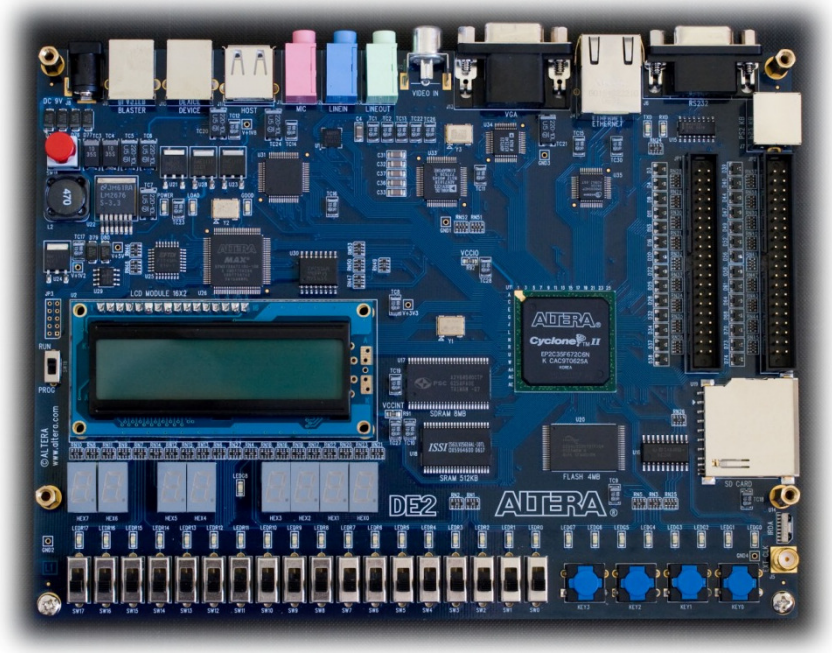
Internet video camera

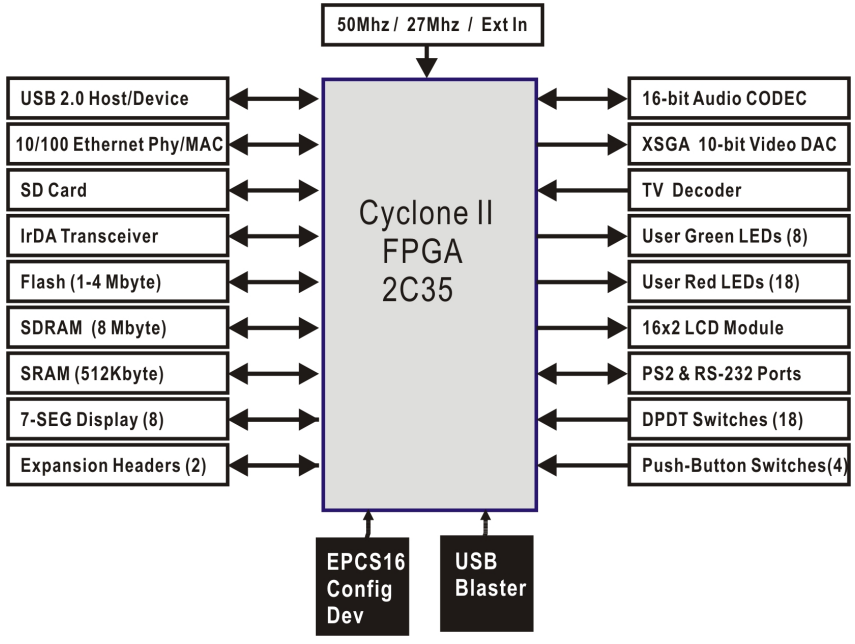


Audio FFT

Video Effects

2007–2013: Terasic DE2 (Altera Cyclone II)





2007–2013: Terasic DE2 (Altera Cyclone II)

Nios II soft processor

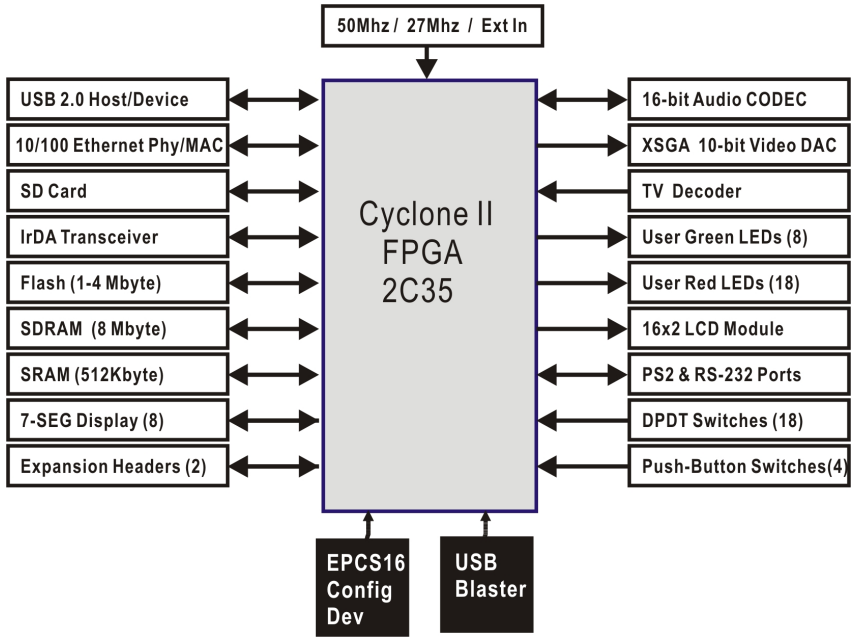
Similar peripherals to XSB

Dedicated pins per peripheral

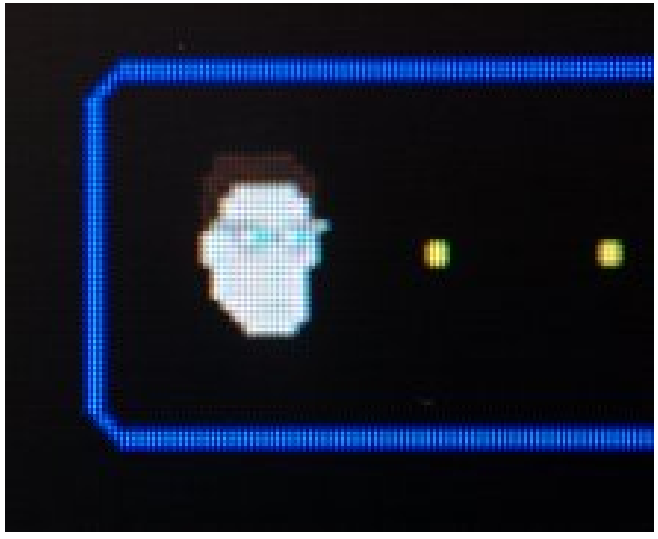
No operating system

VGA easy;
Ethernet hard;
USB impossible

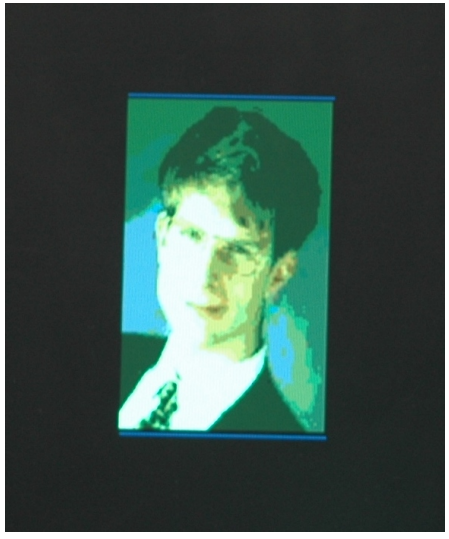
Still used VHDL



DE2 Projects

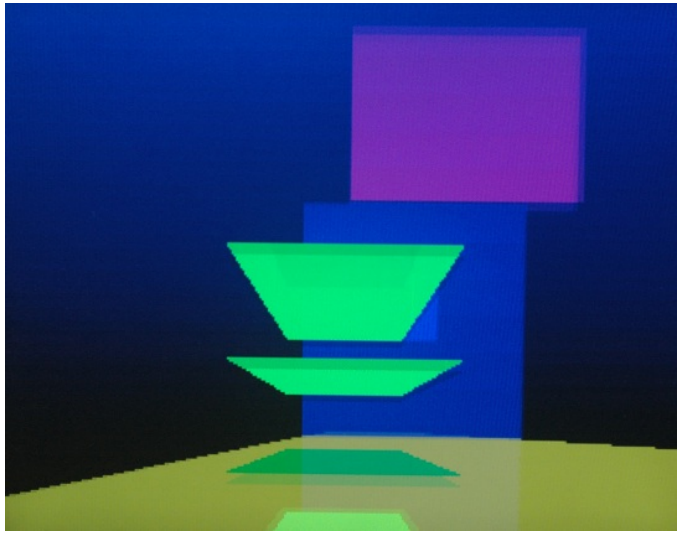


Pac-Edwards



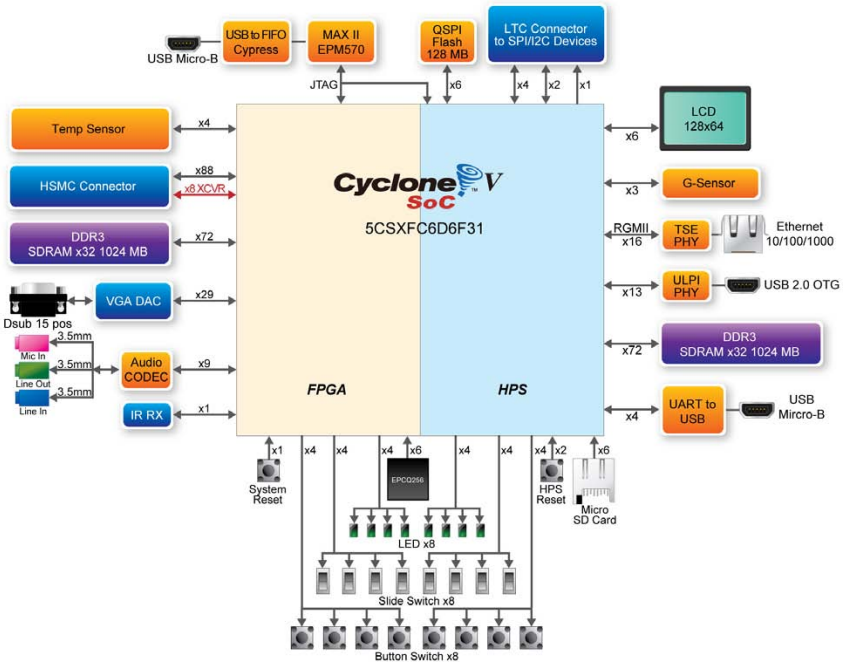
Digital Picture Frame

Encrypted video



Real-time ray tracer

2014–2016: Terasic SoCKit (Altera Cyclone V)



2014–2016: Terasic SoCKit (Altera Cyclone V)

2 ARM9 Hard Processor Cores

Linux: TCP/IP, USB

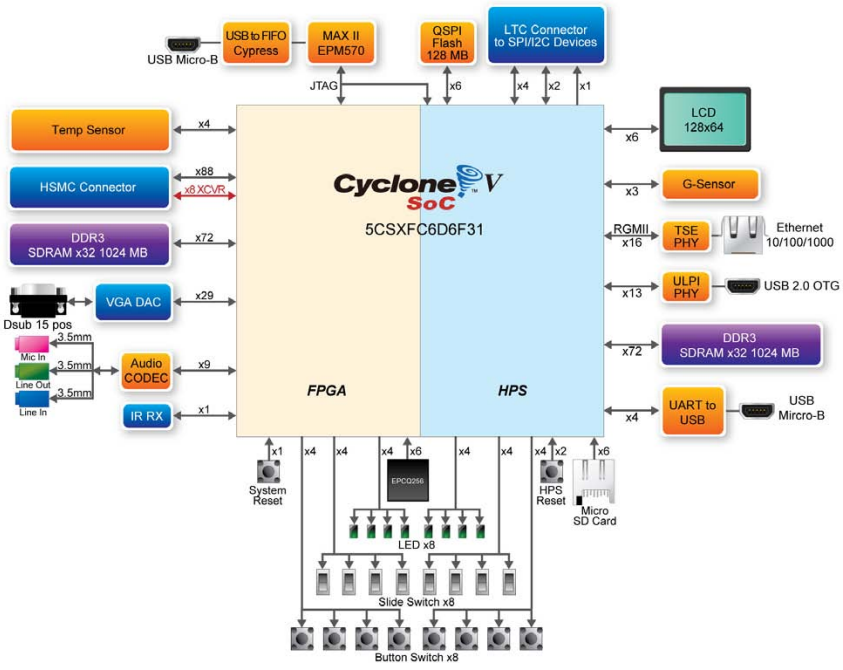
Students write device drivers

Switched to System Verilog

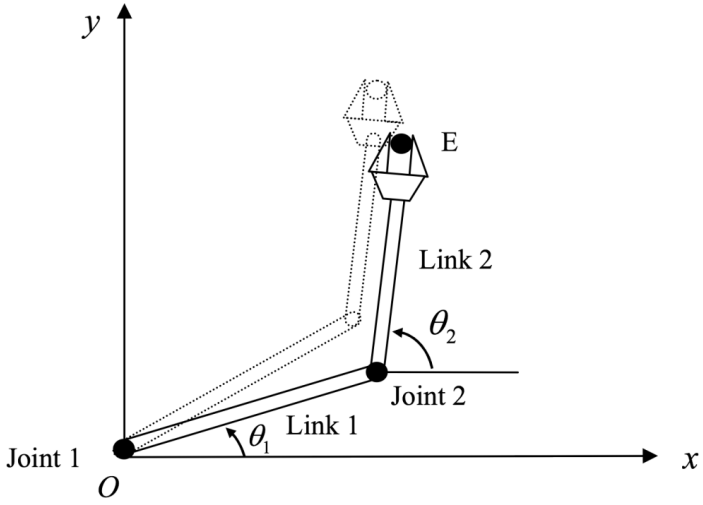
Boot, run diskless (PXE server)

No external SRAM, video input, 7-segment displays

Fragile micro-USB connectors

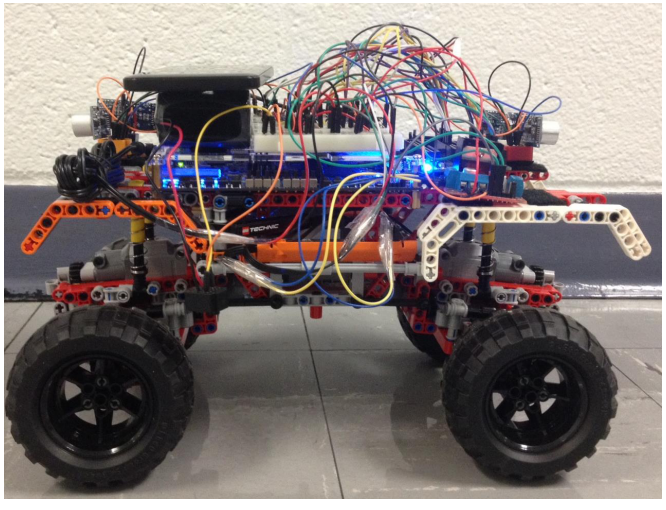


SoCKit Projects



Inverse Kinematics Accel.

Pottery Game



Auto-parking car

Game of Life

Open Questions

Next generation of boards: DE10-Standard or DE1-SoC or ?

How much “friction” to apply to the students? What should they be given vs. what should they develop themselves?

Should students be allowed to specialize? Is it OK that students take the class and merely sharpen their existing hardware or software skills?

Is the “dynamic range” of skills I require unrealistic?