ENCLUSTRA
FPGA SOLUTIONS

Full Linux on FPGA

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Enclustra GmbH

- FPGA Design Center
  - Founded in 2004
  - 7 engineers
  - Located in the Technopark of Zurich
  - FPGA-Vendor independent
- Covering all topics of FPGA based system design
  - Firmware
  - Hardware
  - Software

Design Services

- FPGA system design
  - FPGA firmware design
  - FPGA hardware design
- Embedded software development
  - Application development
  - Standalone and operating system based FPGA systems
  - Full Linux systems on FPGA

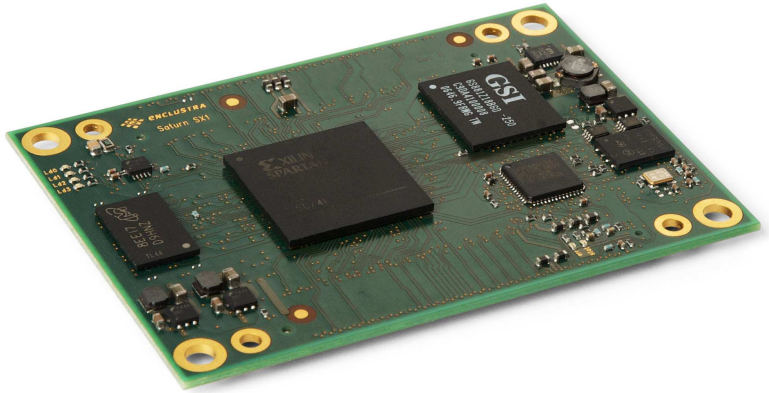
Partnerships

- Xilinx Alliance Program

- Altera Consultants Alliance Program

- Lattice LEADER

FPGA Modules



- Saturn SX1
  - DSP and SoPC optimized FPGA module
  - Xilinx Spartan-3A DSP 1800/3400 FPGA
  - Ideally suited for Linux on FPGA systems
  - For DSP applications: Direct MATLAB / C interface via USB 2.0
- Apollo
  - Saturn Starter: Evaluation base board
  - Evaluation platform for rapid prototyping
  - Video, TFT/touch, networking, drive control, Camera Link, ...

ClustraBus IP Cores

- ClustraBus: vendor- and platform-independent bus system
  - Highly configurable interconnect solution for SoPCs
  - Combines the advantages of Avalon, PLB and Wishbone
  - Available as VHDL source code
- ClustraBus IP cores
  - Bridges (Avalon/PLB/Wishbone)
  - Memory controllers (DDR/DDR2/QDR2/Flash etc.)
  - Peripheral controllers (TFT/DVI/SPI etc.)
  - Coming soon: Drive IP (SM/DC/BLDC)

FPGA

- Field Programmable Gate Array
  - Allows development of custom digital hardware in VHDL / Verilog
  - Logic cells (260 - 758’784)
  - Memory blocks (1 - 2’128)
  - DSP multiply-accumulate blocks (0 - 2’016)
  - I/O pins (23 – 1’200)
- Lower prices, higher densities every other year (65 nm / 45 nm)
- Product tables of the most common FPGAs: www.wikifpga.com

FPGA – Advantages and Possibilities

- Reconfiguration / field upgrade
  - → Easy design changes and fixes
- True parallelism
- Deterministic timing behavior of hardware
  - → Real time capability
- "Hardware" delivered as source code or net list
  - → Long term availability
- Adapting the system to the problem

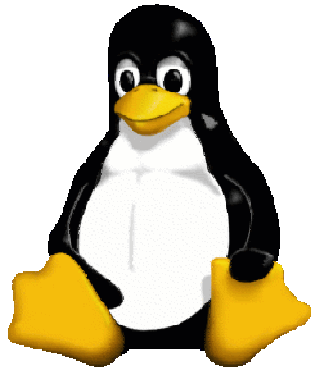
Soft Processor

- Processor implemented in reconfigurable logic
  - E.g. Xilinx MicroBlaze, Altera Nios II, Lattice Mico32, (PowerPC)
- Combining advantages of hardware and software solutions
- Developing application specific SoPCs
- Running from standalone applications to full operating systems on a FPGA based single-chip system
  - Example: Linux Kernel 2.6

Soft Processor – Configurability

- Floating point unit (FPU)
- Memory management unit (MMU)
- Cache sizes
- Arithmetic logic unit (ALU)
  - Multiplier, divider, shifter, ...
- Number of cores
- Attached peripherals (SPI, I2C, TFT, Ethernet, CAN, etc.)
- Attached custom user logic

Linux

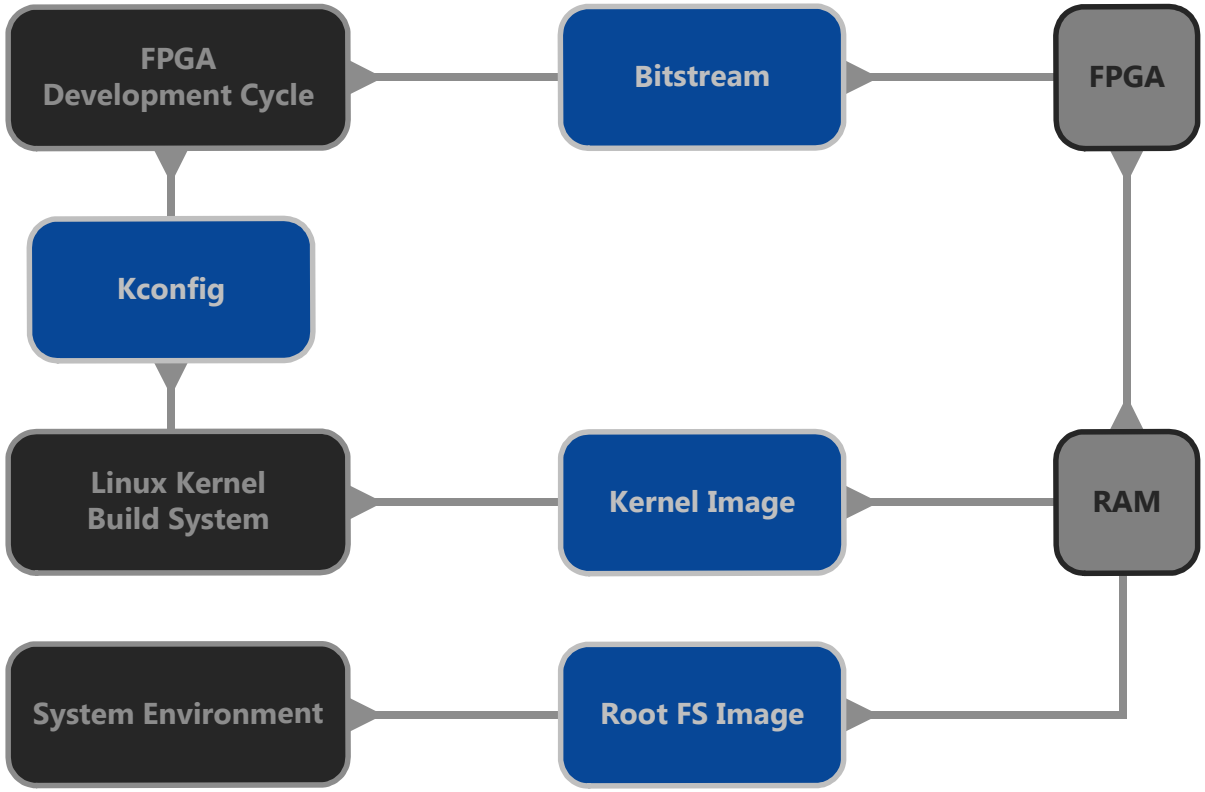


- Open source operating system
  - Can run with or without MMU
  - Supported architectures: Microblaze, Nios II, Mico32, PowerPC, etc.
- Wide range of configuration possibilities
  - E.g. drivers, system environment, also focus on embedded systems
- Possible to achieve a relative small memory footprint
  - Demo system runs with 4 MB Flash and 16 MB DDR2 memory
- Comprehensive selection of existing applications
  - E.g. webserver, multimedia applications, user interfaces

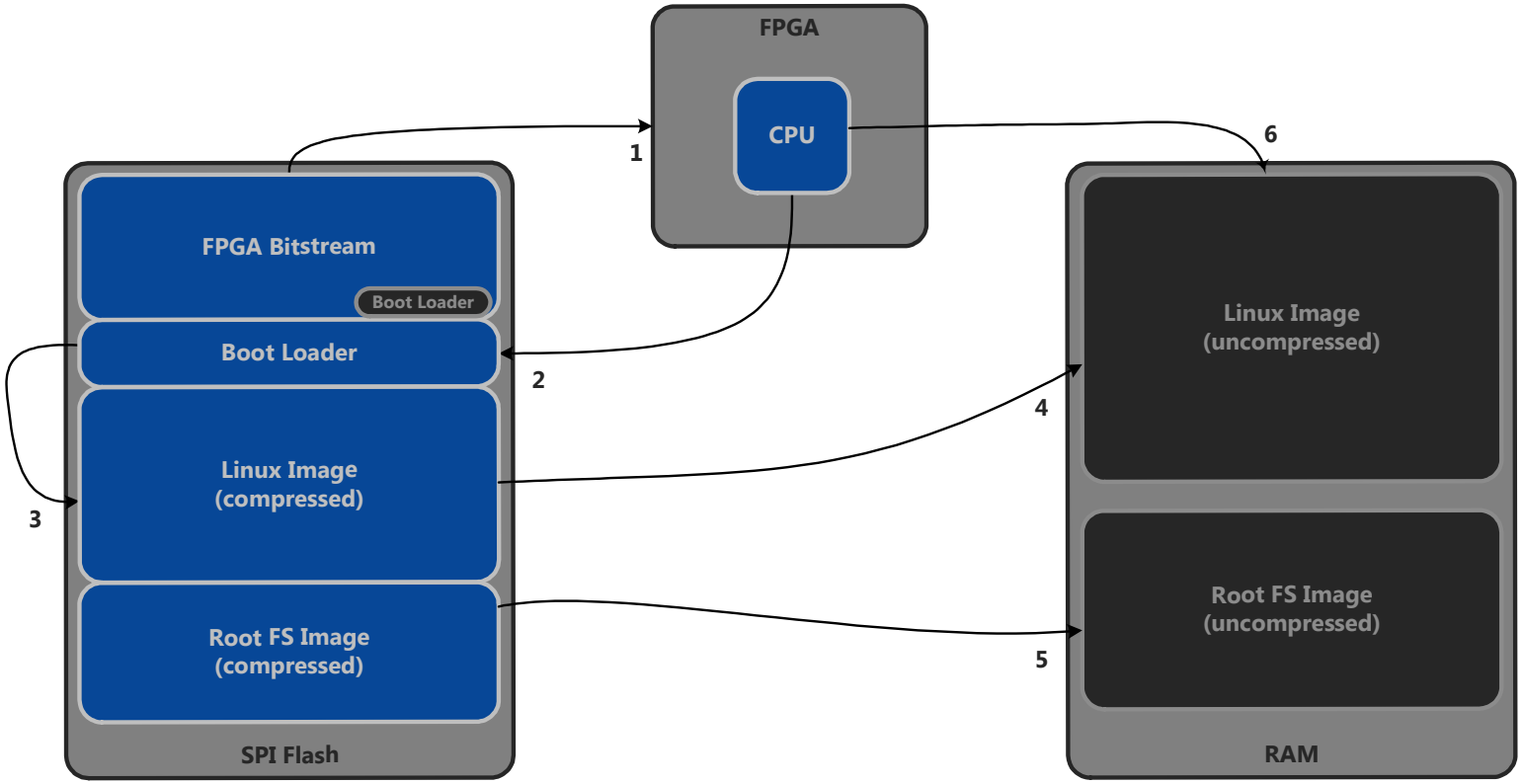
Linux – Advantages

- Fully functional and easily extendable operating system
  - True preemptive multitasking
  - Network stack and protocol suite
  - General and special purpose file systems
  - User interfaces (Shell, X)
  - Scripting languages
  - Sophisticated driver API
  - Wide range of pre-existing driver and driver subsystems
  - ...

Linux on FPGA – Implementation



Linux on FPGA – Boot Process



Linux on FPGA – Boot Process

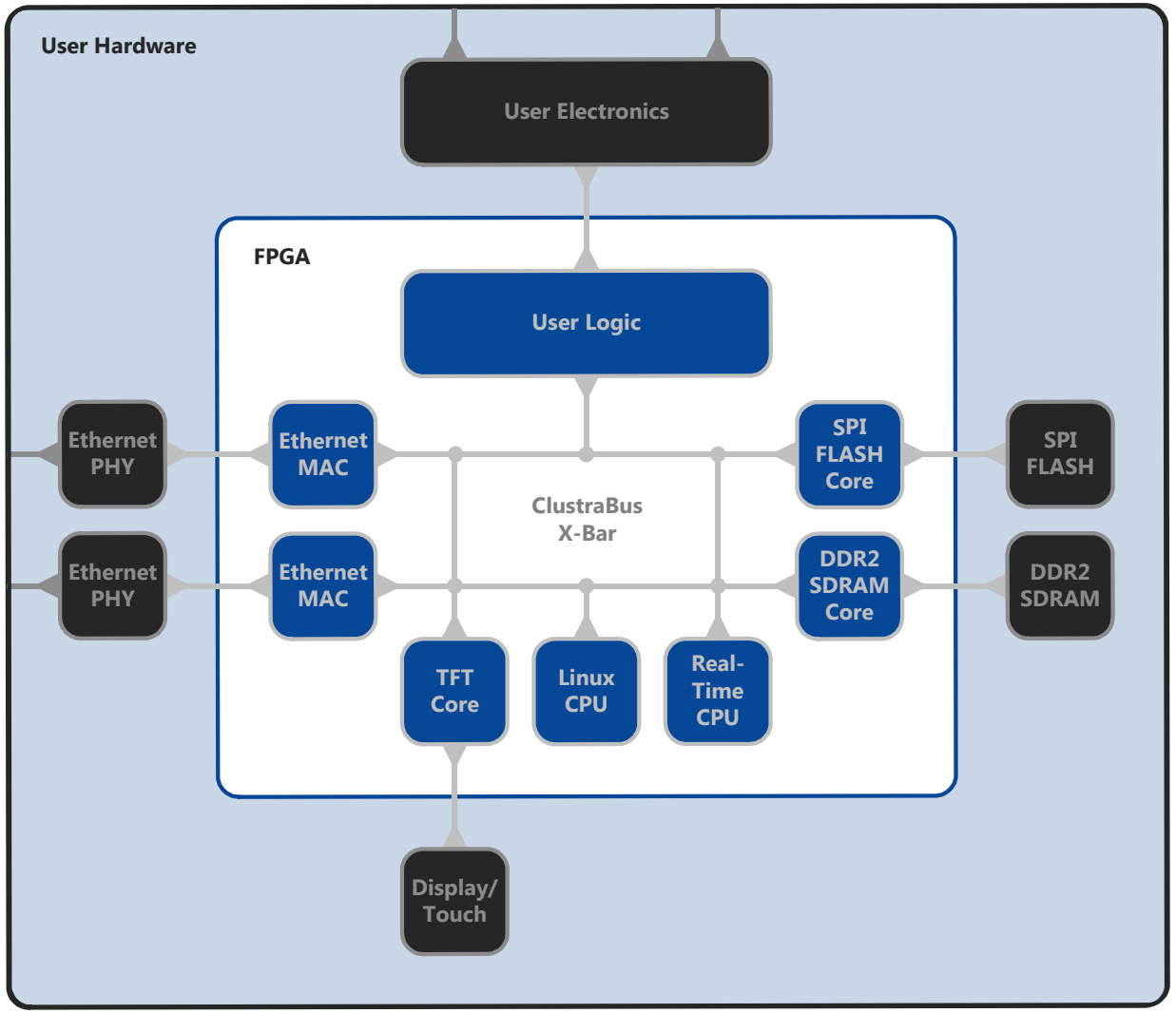
1. FPGA loads configuration bitstream from SPI FLASH
2. Soft processor starts execution of boot loader
3. Boot loader uncompresses and copies Linux data to RAM
4. Uncompressed Linux image is copied to RAM
5. Uncompressed root file system is copied to RAM
6. Soft processor starts execution of Linux kernel

Linux on FPGA – Distributions

- µClinux
  (MicroBlaze noMMU, Nios II noMMU, Mico32, PowerPC)
- PetaLogix PetaLinux
  (MicroBlaze noMMU, MicroBlaze MMU)
- LynuxWorks BlueCat Linux
  (Microblaze noMMU, MicroBlaze MMU, PowerPC)
- Wind River Linux
  (Nios II noMMU, Nios II MMU, PowerPC)
- MontaVista Linux
  (PowerPC)

Linux on FPGA – Example Project

We are actively looking for customer projects in this area.



Summary

- FPGAs allow the development of application specific digital hardware
- Soft processors additionally allow the development of complete SoPC systems
- Linux provides sophisticated driver API and a full-blown system environment for software development

→ Linux on FPGA: total freedom and flexibility in the development of embedded systems

Demo System

- Xilinx Spartan-3A DSP FPGA
- Xilinx MicroBlaze soft processor with MMU
- Petalogix PetaLinux, Kernel 2.6
- Adapted drivers for
  - TFT display controller
  - PS/2 keyboard
  - Address-mapped SPI FLASH
  - Ethernet
- TFT display with frame buffer console and XServer

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Thank you for your attention

Questions?

For further information about Linux on FPGA,
please don't hesitate to contact me:

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