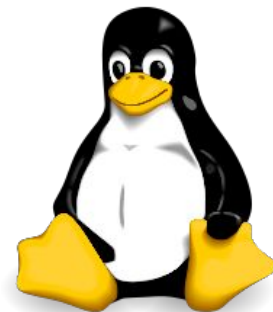
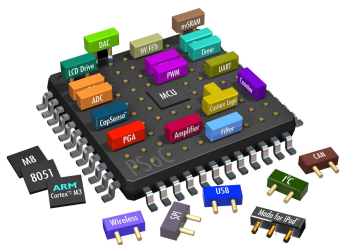


SoC-powered Linux

Benefits of Linux-powered SoC-devices



Presentation plan

- Company profile
- SoC Altera Cyclone V Architecture
- Booting Linux: SPL, U-boot, kernel
- Developing NIC
- Benchmarks
- Troubles



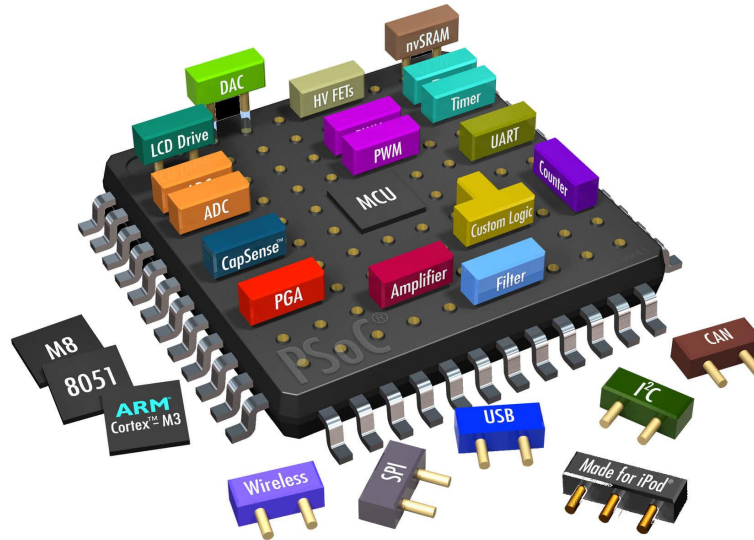
STC Metrotek

- 12 years of RnD experience
- Russia, Saint-Petersburg
- Development and production of measurement equipment
- Telecommunication channels verification: E1, Datacom, Ethernet (10/100/GbE/10G/100G), fiber optics
- Network packet analysis and processing at line rate
- From idea to complete to “out of the box” solution
- Linux inside!

STC Metrotek

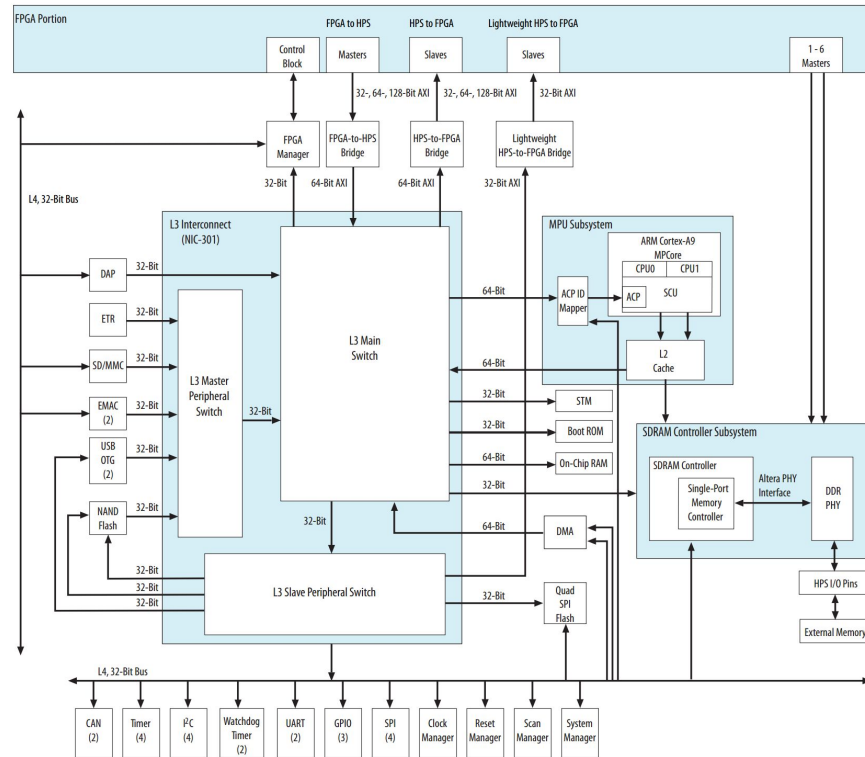
System On Chip

one chip integrates many components



SoC block diagram

Figure 1-2: HPS Block Diagram



Altera SoC = HPS(CPU) + FPGA

ARM

ARM Processor System

Dual Core ARM Cortex-A9
MPCore Processor

Hard
Memory
Controller

Peripherals

ALTERA

28-nm FPGA

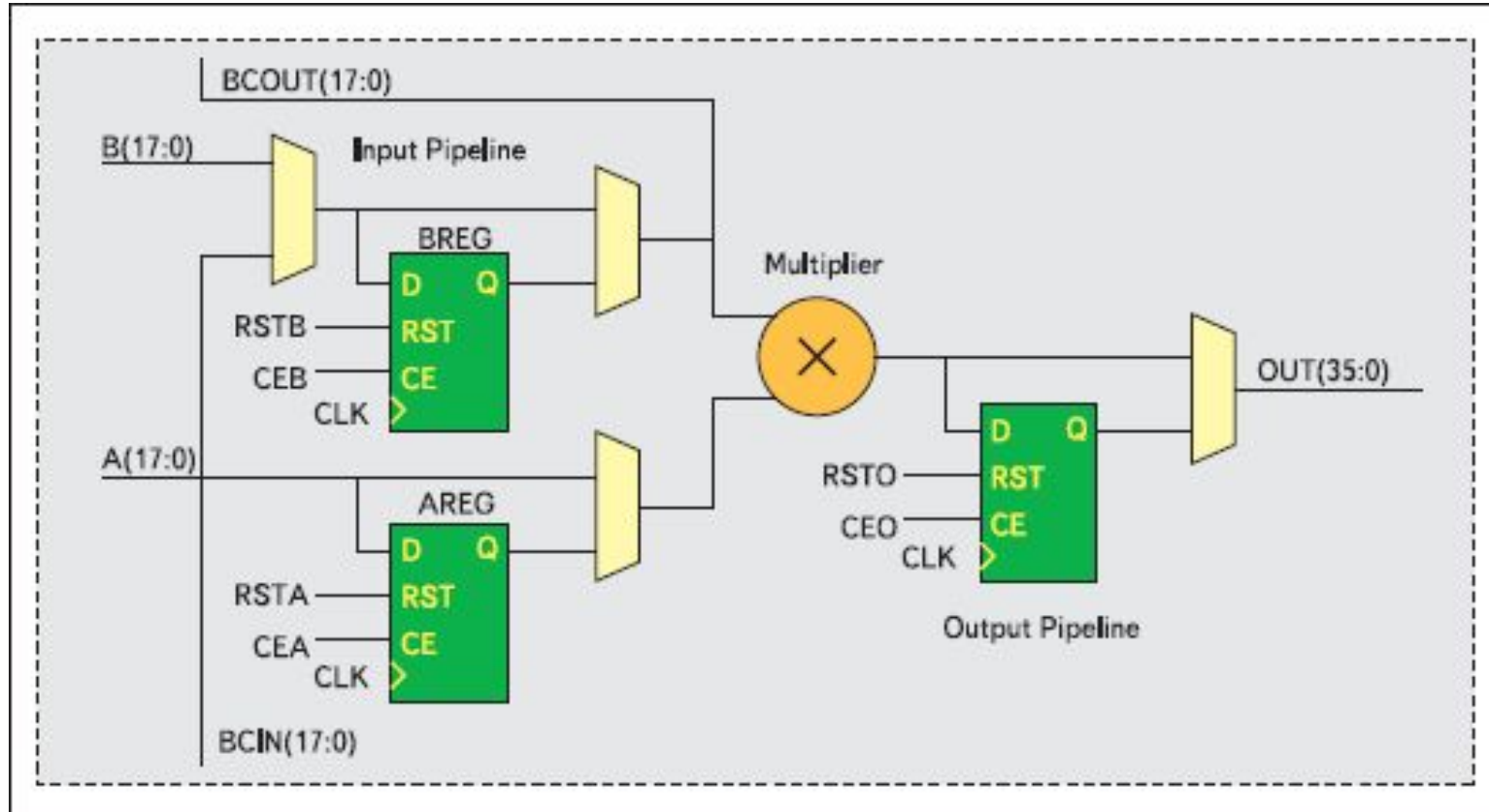
Cyclone V

ALTERA

SoC FPGA

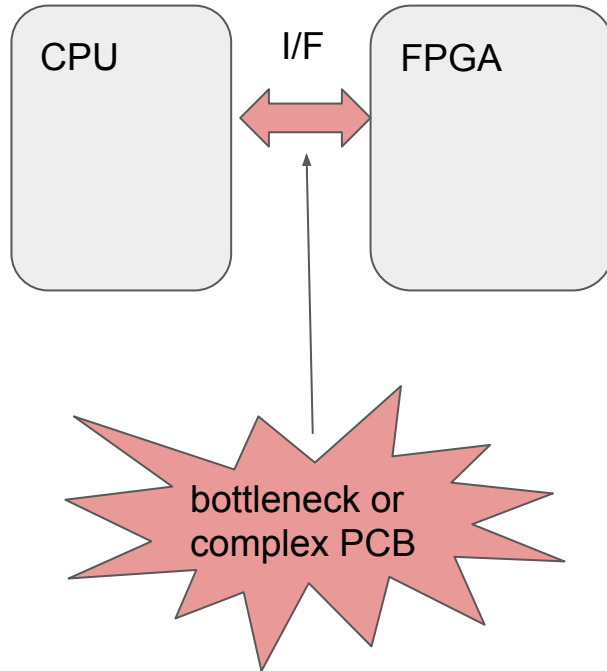
Cyclone SoC V

FPGA - Field Programmable Gate Array

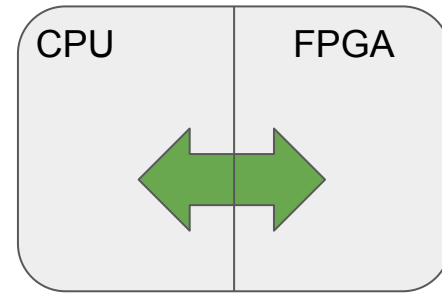


Why use SoC?

Old school

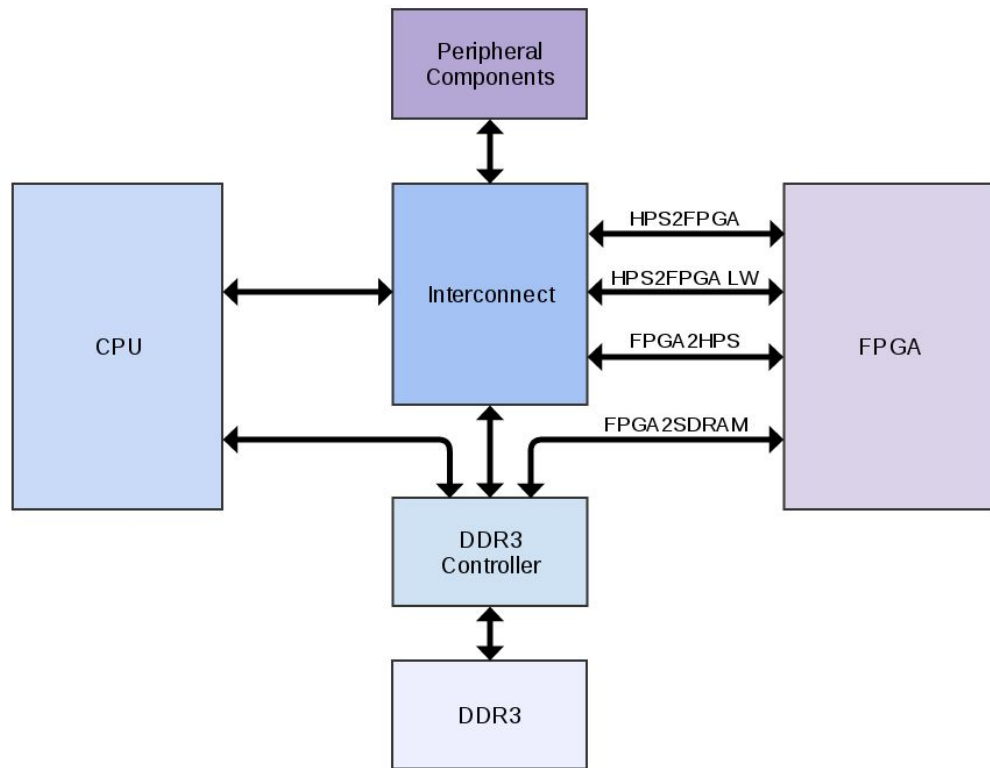


Modern design

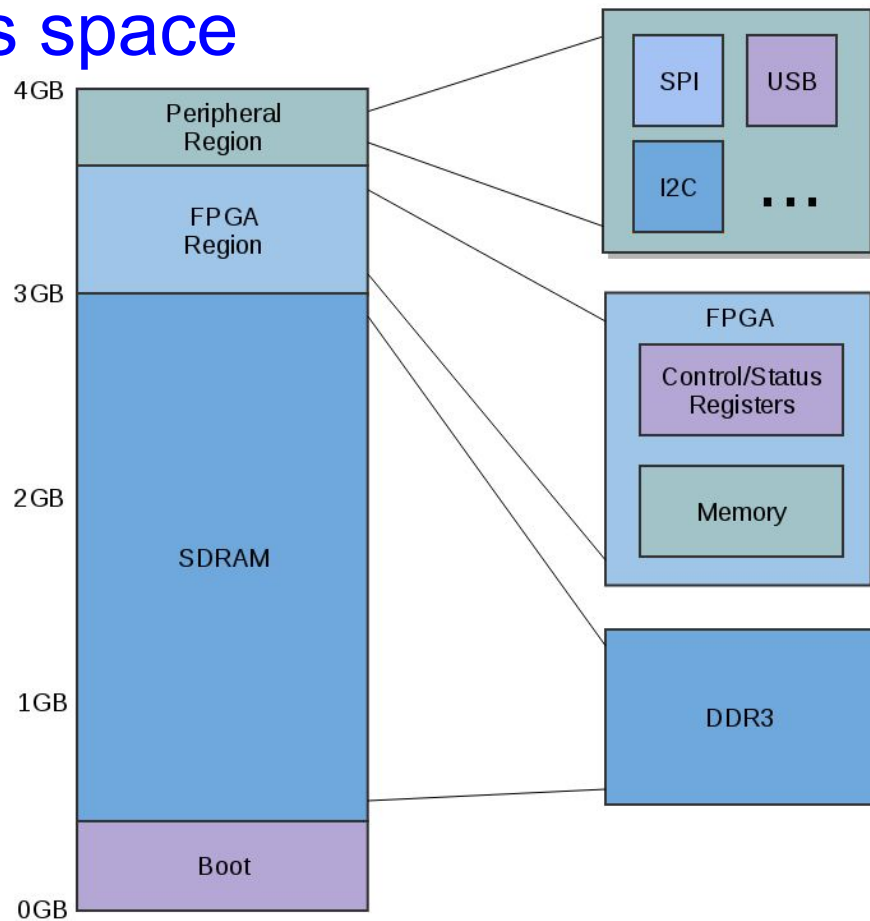


SoC data flows

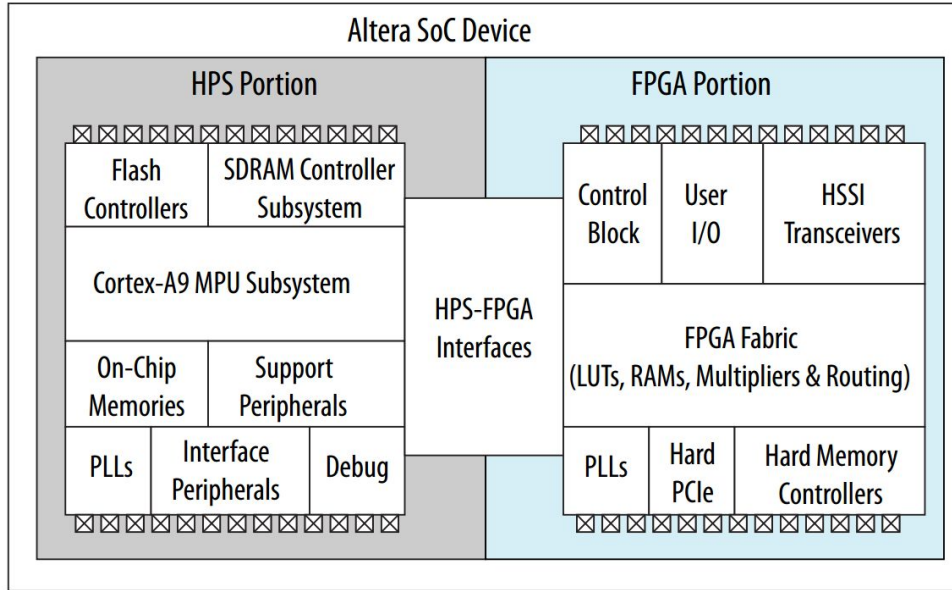
- Direct memory access
- Interconnect
- Dedicated HPS-FPGA interfaces



CPU address space

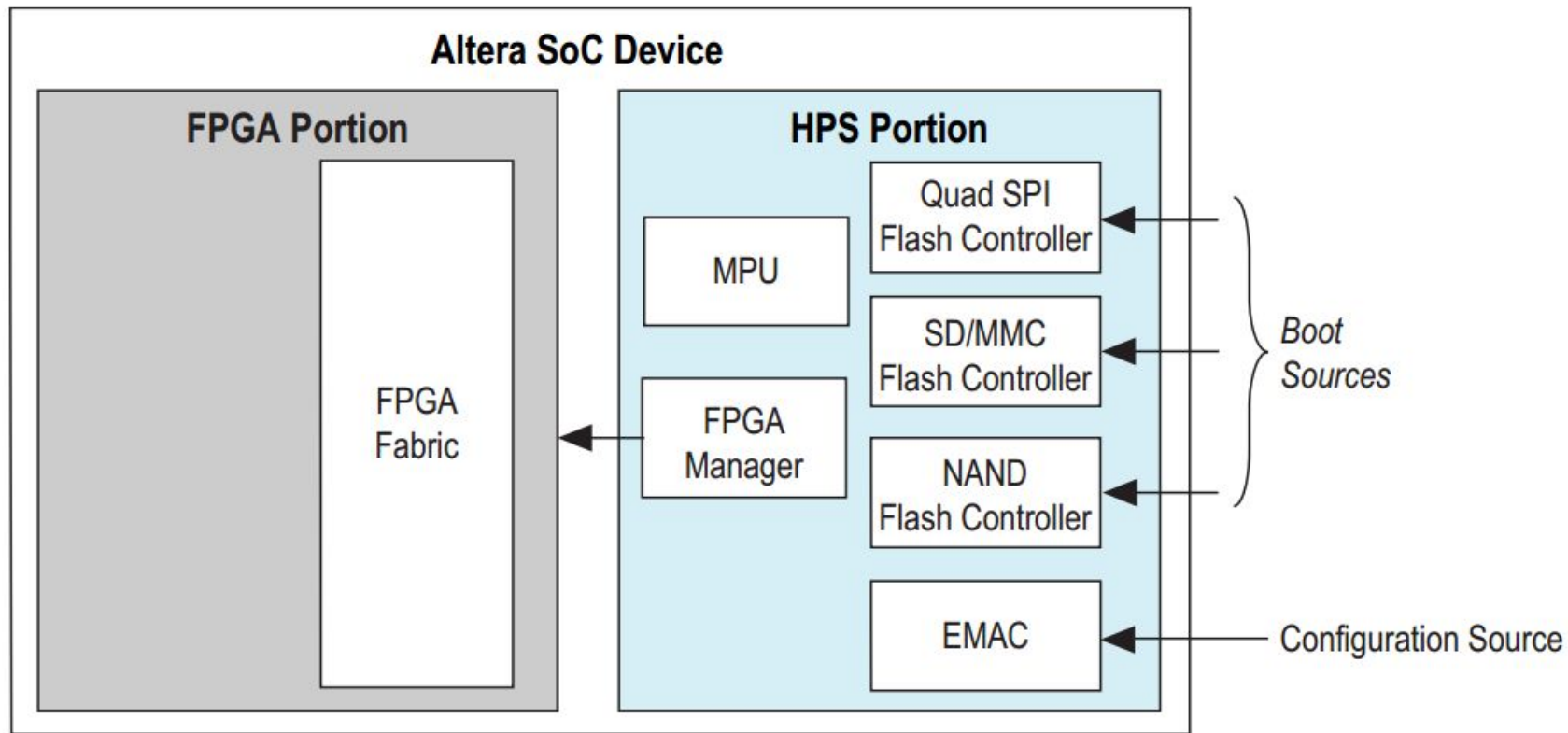


SoC architecture

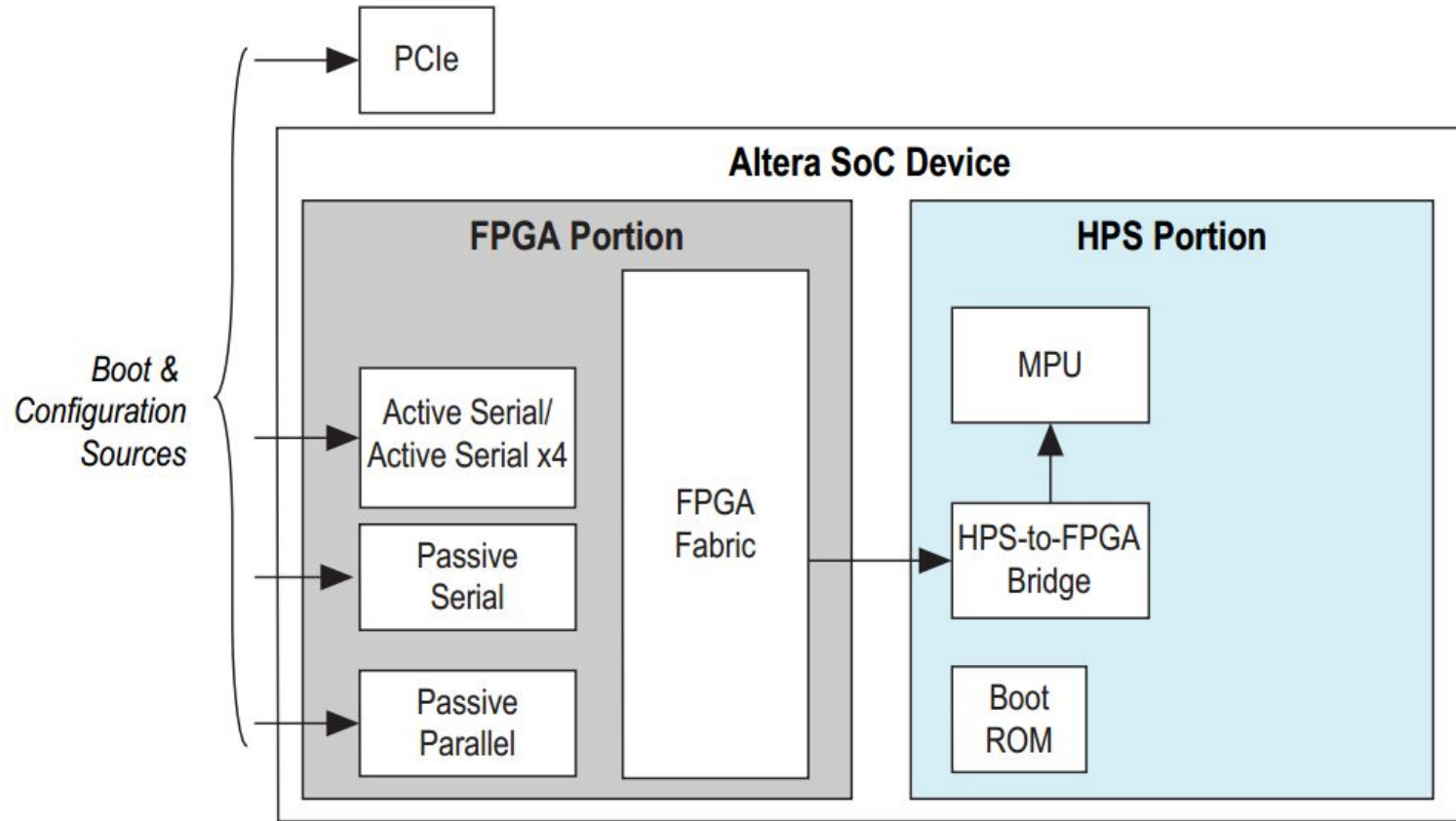


- Independent HPS and FPGA
- Boot sources: SD, QSPI, etc...
- Independent flexible configuration (HPS or FPGA initiated)
- Dedicated memory for FPGA registers
- High-speed interfaces

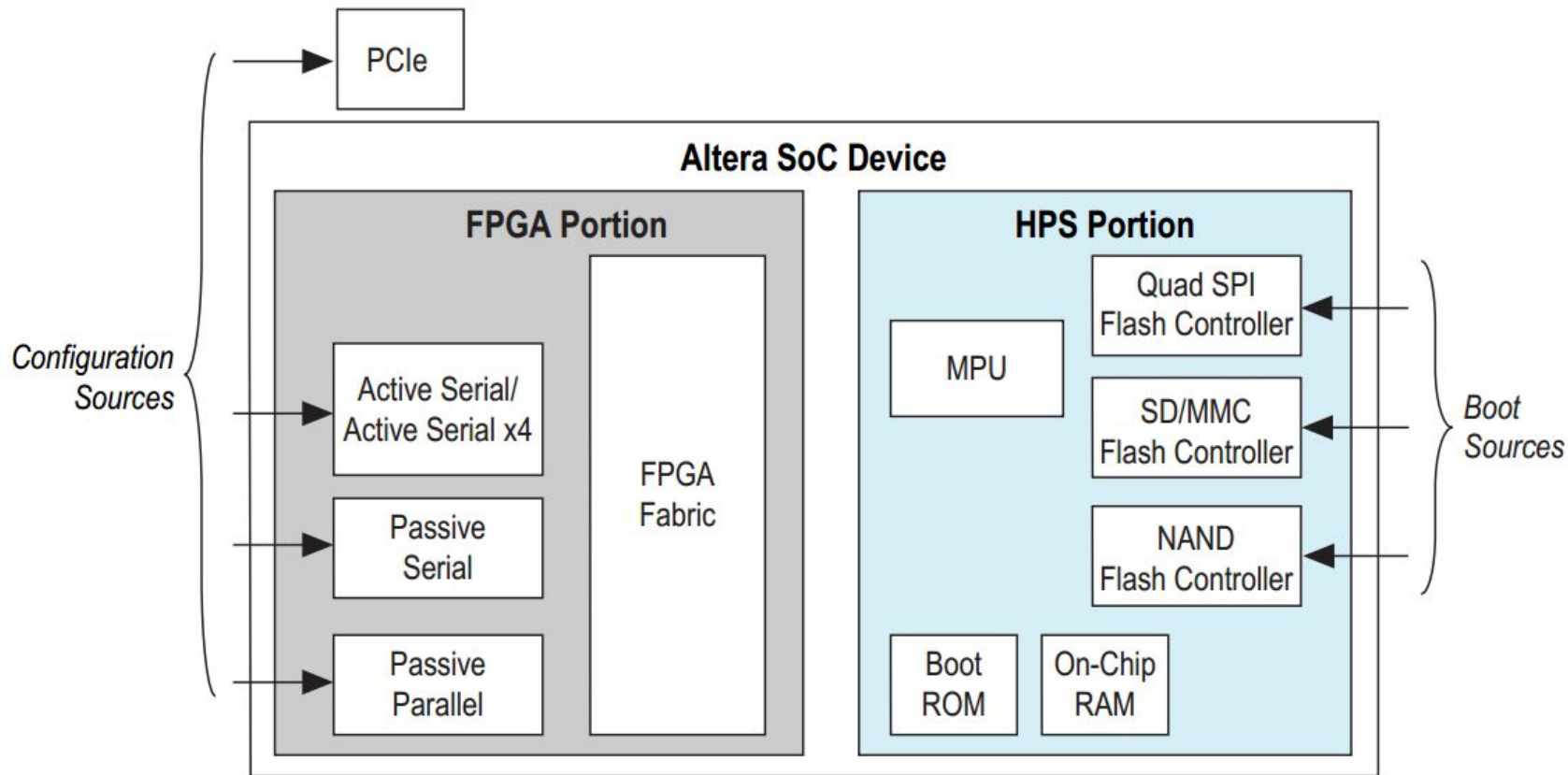
CPU boots first



FPGA boots first

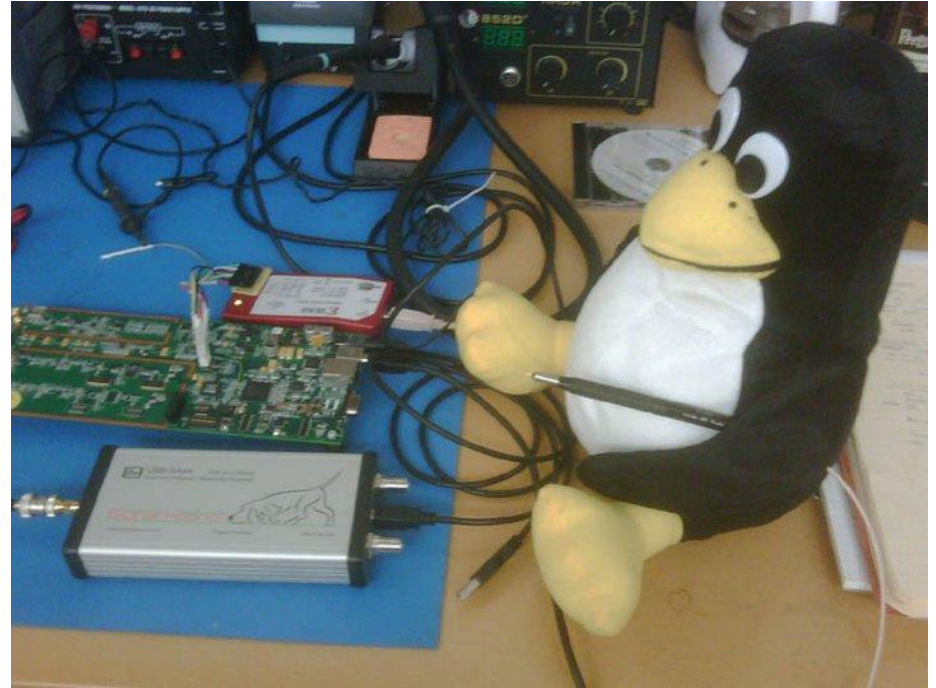


HPS and FPGA boots independently

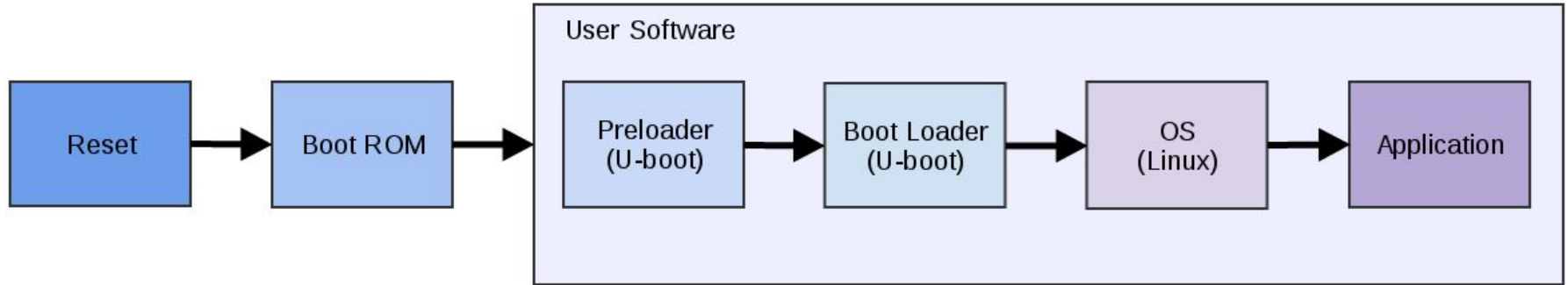


Booting Linux

- preloader
- U-boot + environment
- device tree
- Linux kernel
- rootfs



HPS Boot flow



Preloader + U-boot

Preloader

- DDR initialization
- memtest
- basic synchronization clock setup



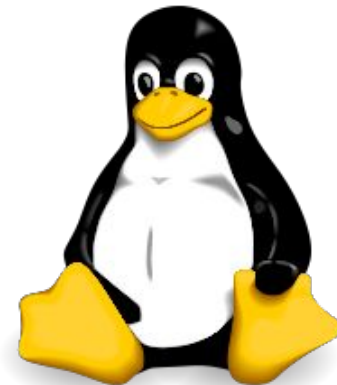
U-boot

- access to peripheral (SD/USB/Ethernet/i2c/etc..)
- filesystem support (fat/ext2)
- flexible boot configuration (boot from TFTP, RAM, etc...)
- scripting, flexibility
- direct memory access

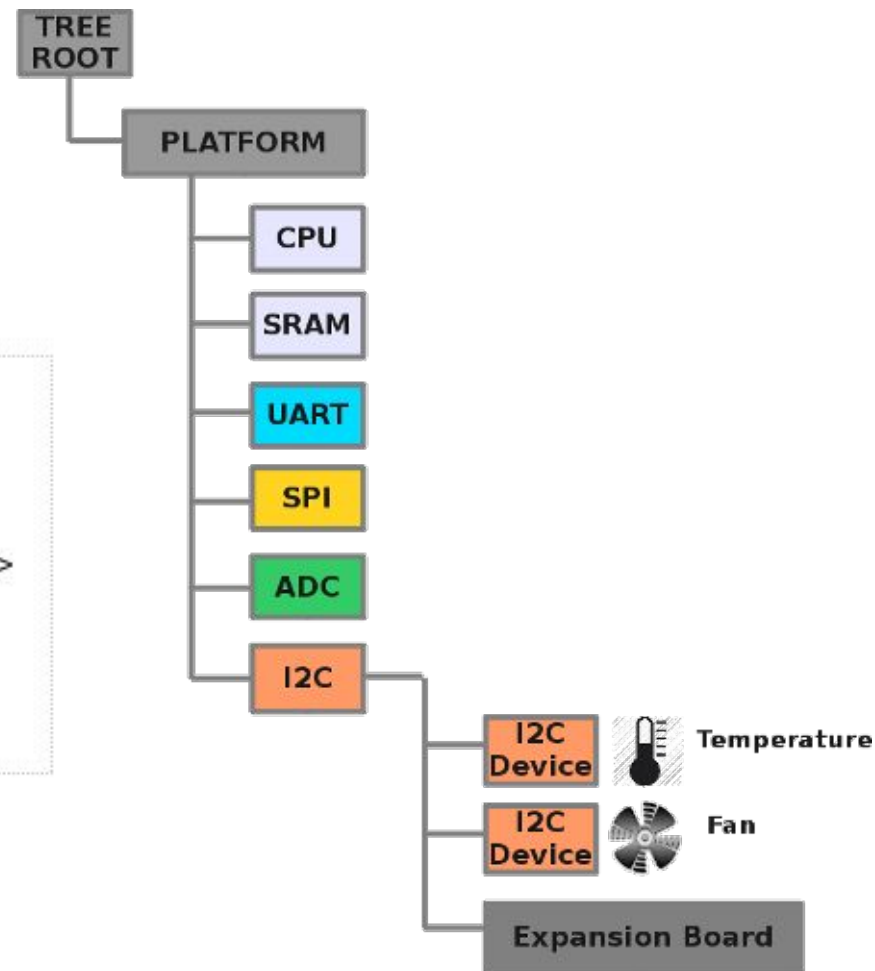
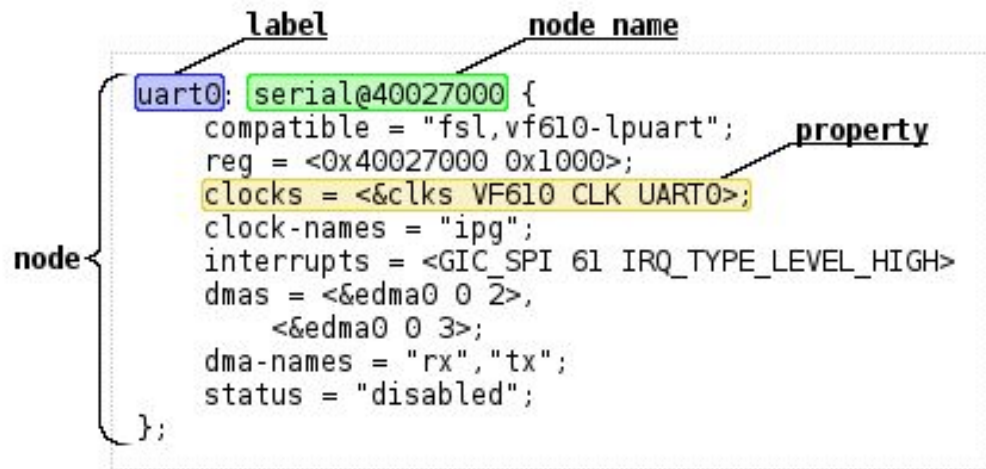


Linux kernel

- `github:altera-opensource/linux-socfpga`
- v 3.18.0



Device tree



Booting FPGA

- Load fpga manager module
- Ensure that FPGA has been detected -- file **/dev/fpga0** should exist
- Get proper FPGA firmware file -- **firmware.rbf**
- Load it to FPGA -- **cat firmware.rbf > /dev/fpga0**
- Ensure that it has been loaded -- **cat /sys/class/fpga/fpga0/status**

HPS and FPGA ready for data exchange!



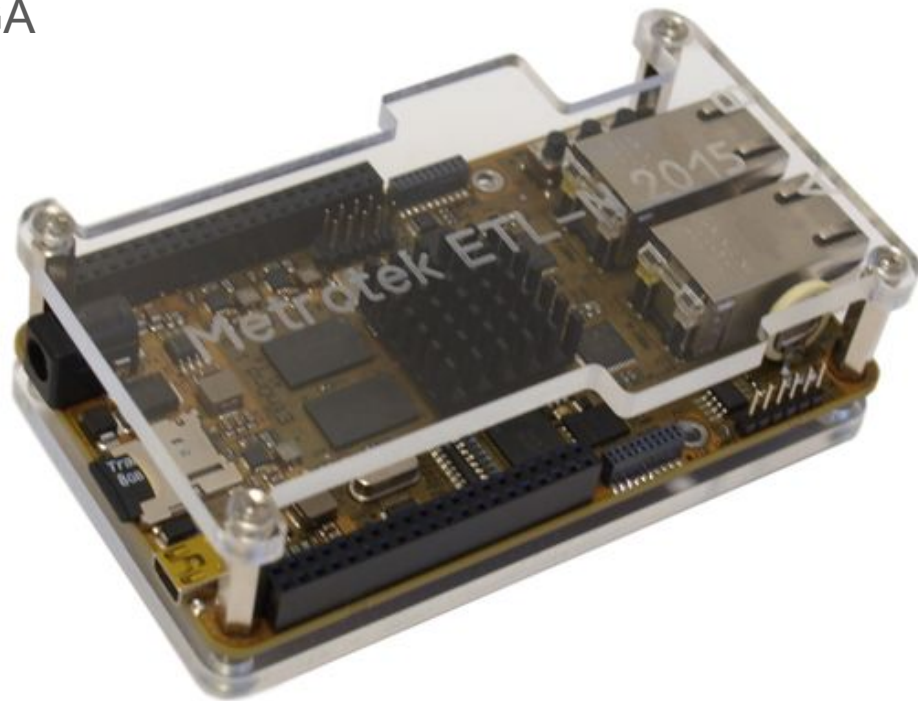
Moving to practical examples



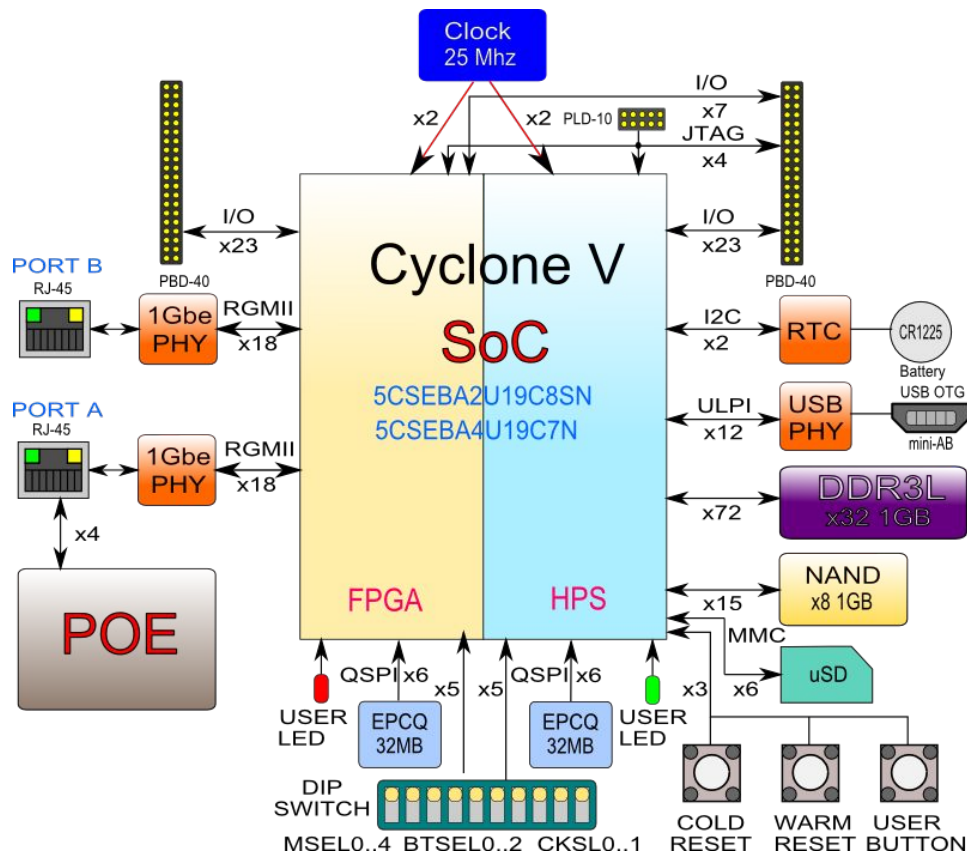
EthOnd development board

Features:

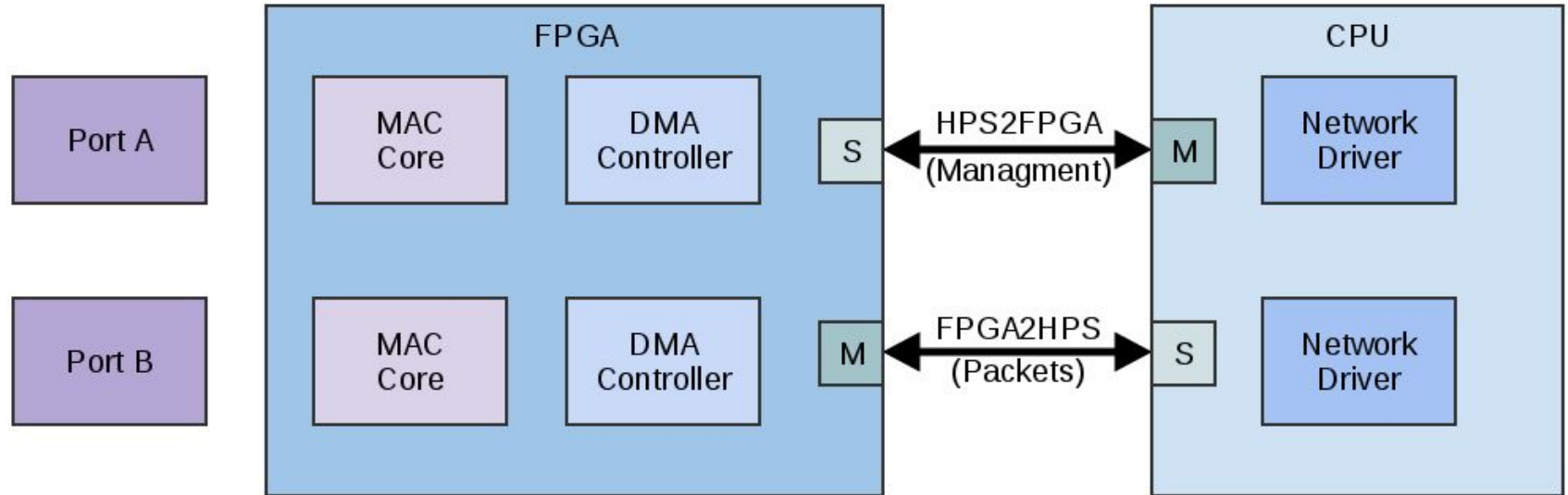
- SoC with 2 ARMv7 Cores and FPGA
- RAM 1GB
- SD-card slot
- 2 x GbE ports
- Shield interface
- USB OTG
- UART console
- Optional PoE
- RTC



EthOnd block diagram



NIC block diagram

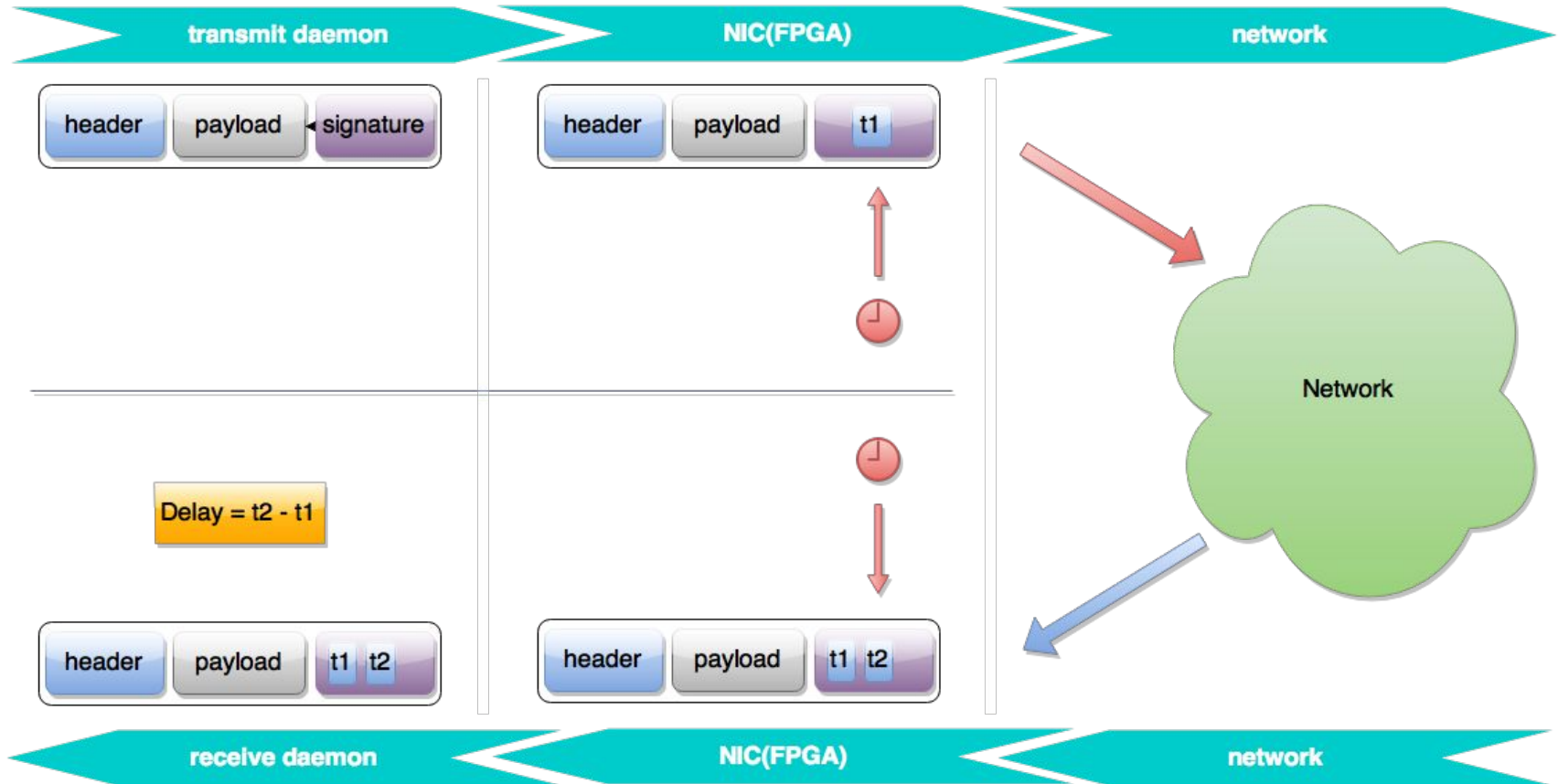


NIC Features

- 2 ports
- NAPI support
- frame sizes 64-1518
- DMA support
- 10/100/1000 Mbps, full duplex
- ethtool support (link speed, link status)
- MDIO support
- low-level timestamping



Packet timestamping



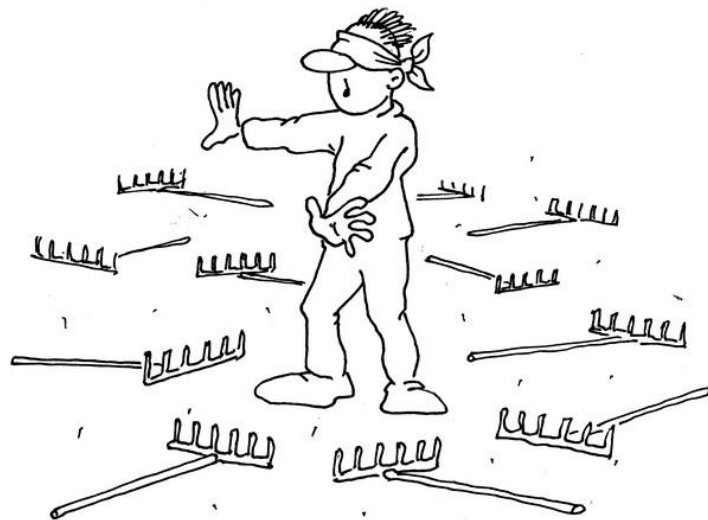
NIC Benchmarks

- TCP iperf on 1500 bytes, TCP window size 85K -- 370 Mbit/s
- UDP for different frame sizes: 16 - 377 Mbit/s
- Delay via office switch - 3 us

A:1000 - B:1000 - 12:26			
Пропускная способность			
Кадр	Нагр. %	Мб/с L2	Тест
64	2.15	16.369	Готово
128	3.71	32.095	Готово
256	7.23	67.031	Готово
512	13.87	133.459	Готово
1024	26.76	262.455	Готово
1280	33.01	325.007	Готово
1518	38.28	377.835	Готово
T:	171.182	R:	0.000 MB
Старт	График	Мб/с L3	Сохран./Загр.

Troubles...

- Hardware MAC (stmmac) did not communicate with FPGA
- Sometimes Qsys generates invalid interconnect
- DDR3: 66 MHz instead of 333 MHz
- i2c controller hangs up
- Linux v3.18 has issue with i2c interrupts
- U-boot does not support ULPI
- Linux 3.12 hangs up with pre-loaded FPGA
- fpga2sdram interface **should** be configured in U-boot
- UART generates thousands of interrupts in 3.18



Pros and cons

- Single chip
 - High-speed interconnect
 - Linux kernel
 - Flexibility
- CPU frequency cannot be changed at run-time
 - High chip temperature
 - Drivers are still crude yet ;)

Thank you!