

INTRODUCTION TO FPGA PROGRAMMING

LESSON 15: PROCESSORS ON FPGA

Dr. Davide Cieri¹

¹Max-Planck-Institut für Physik, Munich

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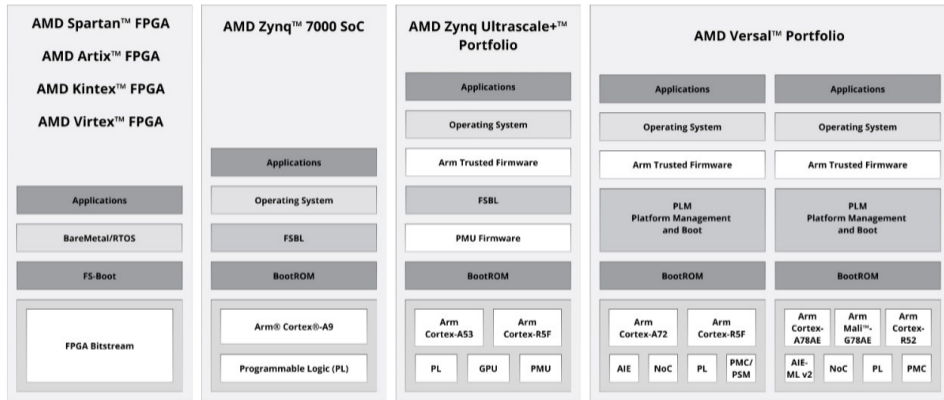
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EMBEDDED PROCESSORS ON FPGAS

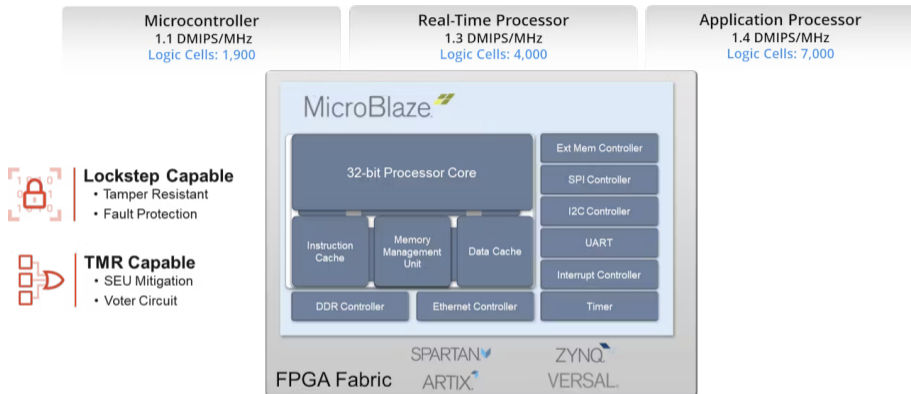
- Even in high performance parallel processing, there might be needs for sequential processing
 - Control, configuration, communication (Ethernet)
- Simple sequential processing can be achieved using FSMs.
- More complex cases might require the usage of embedded processors
- Some devices, called System-on-Chip (SoC), have hard processors already in the fabric
- In AMD FPGAs, you can instantiate a *soft* processor, using the FPGA logic, called MicroBlaze.

AMD EMBEDDED PROCESSOR PORTFOLIO



*MicroBlaze V processor available for 28 nm and newer process nodes

MICROBLAZE



- MicroBlaze is a 32-bit Reduced Instruction Set Processor (RISC)
- Can implement from a simple microcontroller system to a real-time processor running Linux

MICROBLAZE SOFTWARE SOLUTION

Xilinx Supported OS

- > OS Linux
 - >> AMD-Xilinx PetaLinux
- > FreeRTOS
 - >> Vitis™ Tools Integration
- > Stand-alone Bare Metal
 - >> Vitis Tools Integration

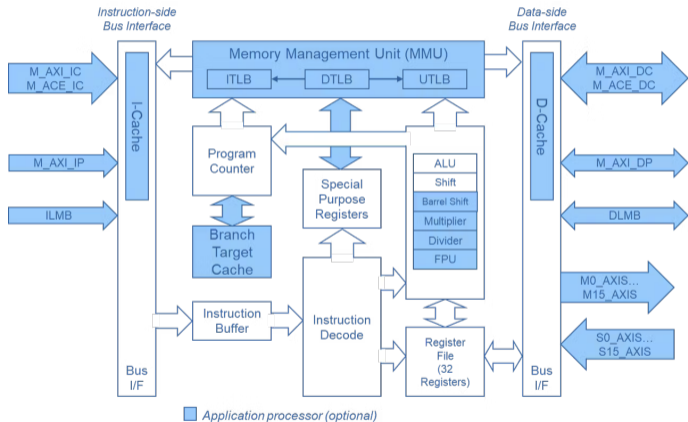


3rd Party Supported OS

- > ENEA OSE
- > ExpressLogic X_WARE IoT platform powered by ThreadX
- > Silicon Labs uC/OS

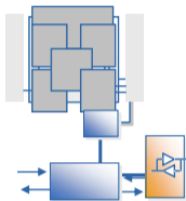


MICROBLAZE ARCHITECTURE



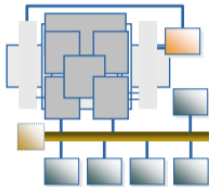
- 32-bit instruction set and general-purpose registers
- 32-bit address bus, extensible to 64
- Optional Floating Point Unit
- Sleep, Hibernate, Suspend Modes

MICROBLAZE APPLICATIONS



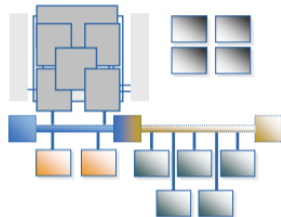
Microcontroller

- Small footprint
- Few to no peripherals
- No OS
- Vast range of applications
- Baseline processing



**Realtime
Processor**

- Medium footprint
- Moderate peripherals
- Small-footprint OS or standalone
- Performance targeted to control, automation and instrumentation



**Application
Processor**

- Large footprint
- Extensive peripherals
- Linux-ready
- Networking & Wireless
- Highest performance

IMPLEMENTING MICROBLAZE

- MicroBlaze processor is distributed by AMD, as an IP core.
 - Highly configurable
 - Presets available for most common applications

The screenshot displays the 'Re-customize IP' window for the MicroBlaze (11.0) configuration wizard. The interface is divided into two main sections: 'Resource Estimates' on the left and 'Configuration Wizard' on the right.

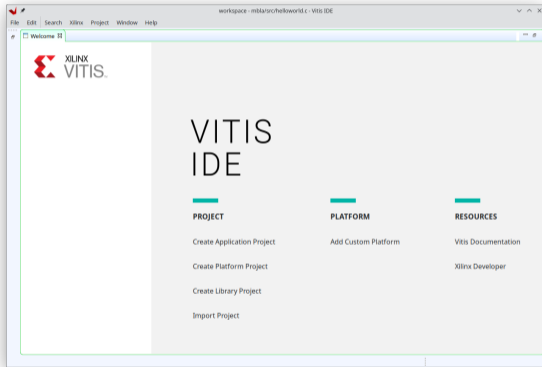
Resource Estimates: A bar chart shows the percentage usage of three resources: Frequency (approx. 950%), Area (approx. 150%), and Performance (approx. 100%). Below the chart, a table shows 'Resource Usage' with 'BRAM' and 'DSP48E' both set to 0.

Configuration Wizard: The main area is titled 'Welcome to MicroBlaze Configuration Wizard'. It includes 'Usage Information', 'Predefined Configurations' (with a dropdown set to 'Current Settings'), 'Select Processor Implementation' (with radio buttons for 32 and 64, where 32 is selected), and 'General Settings' (with a dropdown set to 'PERFORMANCE'). The 'General Settings' section contains several checkboxes: 'Enable MicroBlaze Debug Module Interface' (checked), 'Use Instruction and Data Caches', 'Enable Exceptions', 'Use Memory Management', and 'Enable Discrete Ports'.

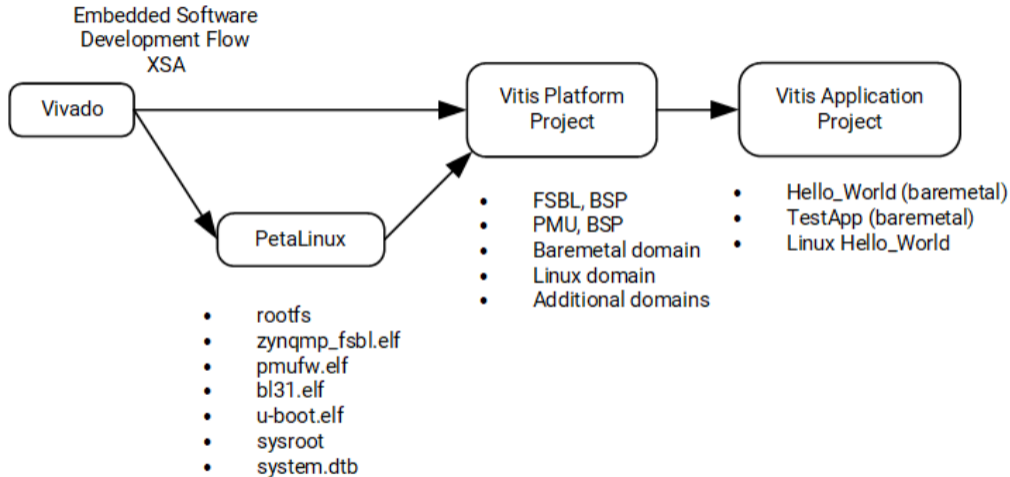
At the bottom of the wizard, there are navigation buttons: '< Back', 'Next >', and 'Page 1 of 4'. At the very bottom of the window, there are 'OK' and 'Cancel' buttons.

VITIS UNIFIED SOFTWARE

- Vitis is the unified software platform from AMD/Xilinx
- Eclipse-based IDE (Integrated Development Environment)
- Development environment for heterogeneous applications on Xilinx devices
 - Software applications running on x86 host processors or Arm[®] embedded processors, compute kernels running in programmable-logic (PL)



VITIS EMBEDDED SOFTWARE DEVELOPMENT FLOW

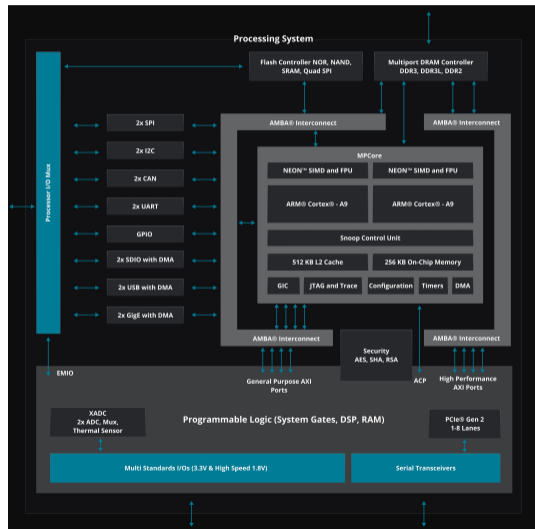


PETALINUX

- PetaLinux is an embedded Linux Software Development Kit, targeting FPGA and SoC designs.
- Based on Yocto, allows developers to customise, build and deploy Embedded Linux solutions
- Supports AMD Versal, Zynq Ultrascale+ and 7000 SoCs, and MicroBlaze processors
- PetaLinux version should be the same as Vivado
 - XSA file compatibility
- [PetaLinux Documentation](#)

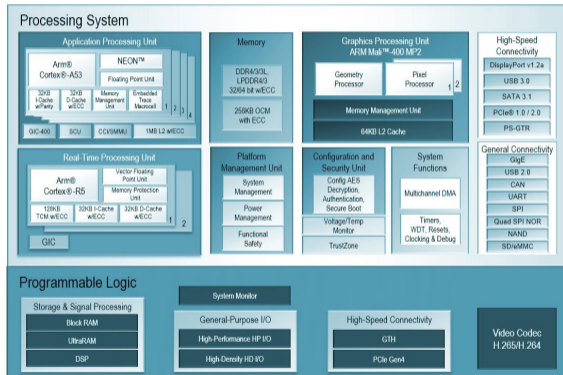
ZYNQ 7000 SYSTEM-ON-CHIP (SOC)

- The Zynq 7000 is the first family of Xilinx device having an hard-processor on the same fabric as the FPGA
- Chip divided into Programmable Logic (PL) and Processing System (PS)
 - PS is an ARM9 CPU (dual or single core)
- Separate IO banks for PL and PS
- Communication between PS and PL via AXI ports



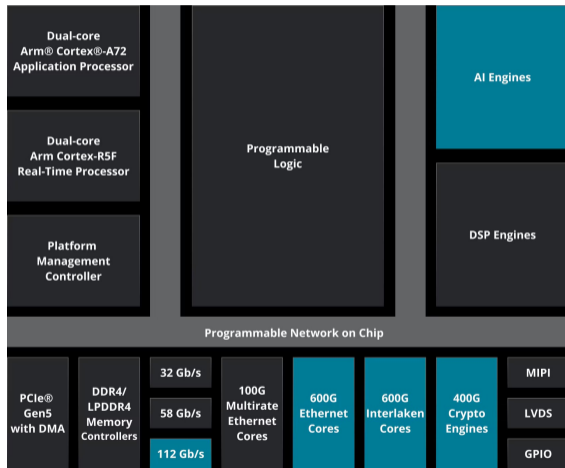
ZYNQ ULTRASCALE+ MULTIPROCESSING SYSTEM-ON-CHIP (MPSOC)

- Zynq Ultrascale+ MPSoCs additionally includes Real-Time Processing Units (RPU), GPUs, and Video Codecs
- Up to Quad Arm Cortex-A53
- Up to Dual Arm Cortex-R5F



VERSAL ADAPTIVE SOCS

- Versal Adaptive SoC is the most powerful device produced by AMD Xilinx
- Currently at the second generation
- In addition to standard processors includes AI and DSP engines, to infer ML applications, and digital signal processing
- Novel Programmable **Network on Chip (NoC)**, to share data between the different



LAB 24: IMPLEMENTING A MICROBLAZE PROCESSOR

The figures in these slides are taken from:

- Digital Design: Principles and Practices, Fourth Edition, John F. Wakerly, ISBN 0-13- 186389-4.
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