

Soft Processors

Jake Humphrey

June 16, 2015

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1 Abstract

This document seeks to provide an impartial comparison of the various Soft Processors on the market.

2 Comparison of Soft Processors

The following metrics will be taken into account:

- Bus Used
- Architecture (MIPS/ ARM)
- Cache
- MMU (Memory Management Unit)
- Protection/User Levels
- License
- Documentation

- Toolchain/Debugger/Monitor/JTAG
- Maturity
- Resources, Speed on target FPGA

2.1 OpenRISC

Developer OpenCores

Bus Used OpenRISC uses Wishbone, an open source specification by OpenCores.

Architecture 32/64-bit Mips-like.

Cache 1–64kB for Instructions and Data each.

MMU Virtual Memory support. TLB with page size 8kB and 16–256 entries.

User Levels User/Supervisor Mode.

License There are two main open source implementations available. A Verilog implementation, OpenRISC 1200, is released under LGPL. Another Verilog implementation, mor1kx, is available under a weak copy-left licence created specifically for it, the OHDL.

Documentation The specification can be found [here](#). Documentation for both implementations are also available at their respective Github pages: Mor1kx, OR1200.

Toolchain A Compiler (based on gcc) and Debugger (based on gdb) are available. See [here](#).

Maturity The OpenRISC 1000 specification has been under development since 2001. Version 1.0 was released in 2012, and Version 1.1 in 2014. The OpenRISC 1200 implementation is stable but not in active development, and is the widely used version according to the OpenRISC project overview. Mor1kx is still in active development, but is stated to be more sophisticated.

2.2 LEON2/3/4

Developer Aeroflex Gaisler

Bus Used AMBA2

Architecture 32-bit. ISA based on SPARC-V8

Cache LEON2: Instruction and Data caches. Set-associative with 1–4 sets and 1–64kB/set. LRR or LRU replacement. LEON3/4: 1–4 sets, 1–256 kB/set. Random, LRR or LRU replacement. LEON4 includes an optional L2 cache. 256-bit internal, 1-4 sets, 16kB–8MB.

MMU SPARC Reference MMU (SRMMU) with configurable TLB

User Levels The User and Supervisor modes of SPARC.

License Gaisler state on their website that LEON2 is available from Atmel (AT697 and AT7913), but I found what appears to be the VHDL source code on Github. LEON3 is available under GPL as part of the GRLIB library. LEON4 is only available under a commercial license from Gaisler.

Documentation LEON3 and LEON4 have documentation.

Toolchain Being SPARC V8 conformant, compilers and kernels for SPARC V8 can be used with LEON processors. Cross compiler BCC. gdb can be used for debugging.

Maturity

2.3 Lm32

Developer Lattice

Bus Used Wishbone

Architecture 32-bit. ISA [here](#).

Cache Configurable between no cache, 8kB I-cache, and 8kB I-cache and 8kB D-cache.

MMU None.

User Levels No separate modes.

License LatticeMico32 is licensed under a free (IP) core license.

Documentation Documentation is available [here](#), but registration is required.

Toolchain GCC supports the LM32 since version 4.5.0, and Binutils since 2.19. gdb and Newlib are also supported.

Maturity Introduced in 2006.

2.4 Microblaze

Developer Xilinx

Bus Used Customisable between CoreConnect PLB, OPB, FSL, LMB, AXI4.

Architecture In terms of its instruction set architecture, MicroBlaze is very similar to the RISC-based DLX architecture, which in turn is based upon the MIPS architecture.

Cache 2kB–64kB Direct mapped write-through or write-back.

MMU Optional. 4GB virtual memory, supports page sizes of 1kB, 4kB, 16kB, 64kB, 256kB, 1MB, 4MB, and 16MB. Page-replacement strategy controlled by software.

User Levels User and privileged modes.

License Proprietary. Available from Xilinx along with the EDK (Embedded Development Kit). A smaller, less functional version with limited target devices is available for free, but the full version costs \$3000–\$6000, depending on the license type. The license also restricts the use of Microblaze to Xilinx FPGAs. LGPL clones also exist in Verilog, VHDL, or MyHDL. See [here](#).

Documentation Rather comprehensive reference manual [here](#).

Toolchain Xilinx provides the Vivado design suite, including an IDE, SDK, Simulator, Analyser, and Synthesiser. Support for Microblaze also exists in gcc as of version 4.6.

Maturity Currently in version 8.50b, under development since 2002.

2.5 Nios II

Developer Altera

Bus Used Altera's own Avalon bus.

Architecture 32-bit RISC architecture, with support for up to 256 custom instructions. 3 different configurations are available: fast (f), standard (s), and economy (e).

Cache Nios II/f has separate instruction and data caches of 512B to 64kB, while the Nios II/s has only an instruction cache, and the Nios II/e has none.

MMU There is an optional MMU and MPU for the Nios II/f. Default is 16-way set-associative cache, the default size depends on the target FPGA but is either 128 or 256 entries or 4 or 8kB. Replacement strategy is set by the software.

User Levels The Nios II supports user and supervisor modes only when the design includes an MMU or MPU.

License The License for the Nios II IP core is around \$500. Currently the Altera website has a redirect loop and I am unable to find information on toolchain licenses.

Documentation Both Hardware and Software development documentation can be found [here](#).

Toolchain Qsys and Quartus for hardware, Altera's Embedded Design Suite for software, based on Eclipse and the GNU toolchain.

Maturity In development since 2004, currently in version 13.1, released in 2013.

2.6 Cortex-M1

Developer ARM

Bus Used ARM Corelink Interconnect

Architecture Three-stage 32-bit RISC, ARMv6M ISA.

Cache No cache, TCM only, up to 1MB each.

MMU None.

User Levels I don't think it has different levels.

License Proprietary, must contact sales team for cost, I think.

Documentation No reference manual specifically for the M1. See the "resources" tab on this page for more information.

Toolchain An extension of Altera's Quartus II. Supported by the ARM microprocessor development kit for software development.

Maturity Couldn't find any information.