

# The HercuLeS HLS environment

Nikolaos Kavvadias  
nkavvadias@ajaxcompilers.com

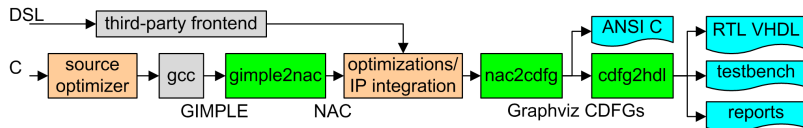
CEO, Ajax Compilers,  
Athens, Greece  
[www.ajaxcompilers.com](http://www.ajaxcompilers.com)



# Introduction

- HercuLeS is a new high-level synthesis tool marketed by Ajax Compilers
- Easy to use, extensible, high-level synthesis (HLS) environment for whole-program hardware compilation
- In development since 2009
- HercuLeS targets both hardware and software engineers/developers
  - ASIC/SoC developers, FPGA-based/prototype/reference system engineers
  - Algorithm developers (custom HW algorithm implementations)
  - Application engineers (application acceleration)

# The HercuLeS flow



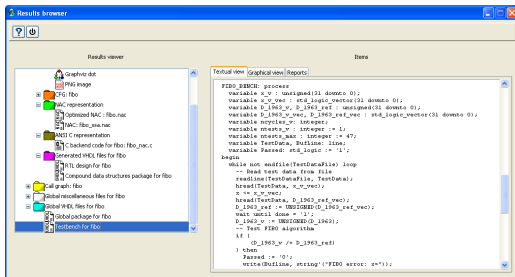
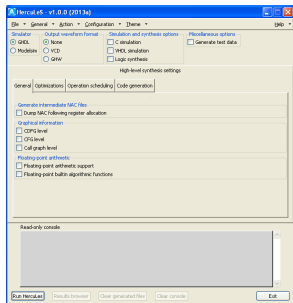
- Optimized C code passed to GCC for GIMPLE generation
- *gimple2nac* translates to N-Address Code (NAC) IR
- HercuLeS = *nac2cdfg* + *cdfg2hdl*
  - *nac2cdfg*: SSA construction/CDFG extraction from NAC
  - *cdfg2hdl*: automatic FSM hardware and self-checking testbench generation
- Modular and extensible flow; support for the basic GMP (multi-precision integer) API/DSL added in 24h (3 days)
  - *mpint.vhd*: MP integer and SLV operators: 500 LOC, 12h
  - *gimple2nac* extensions: 50 LOC, 4h
  - HercuLeS additions: 150 LOC, 8h

# Feature list

- Three licensing models for HerculEoS: FREE (no cost), BASIC and FULL
- FREE version
  - Automatic RTL VHDL code and testbench generation, automatic user-defined IP integration, C frontend, GHDL/Modelsim support, HerculEoS GUI
- BASIC version (+ everything in FREE)
  - Parallel operation scheduling, block RAM inference, arithmetic optimizations, VHDL-2008 floating-point arithmetic support, C verification backend
- FULL version (+ everything in BASIC)
  - VHDL-2008 fixed-point arithmetic support, GMP extensions, register optimization, operation scheduling improvements, C source code optimizer incl. array flattening optimizations

# The HercuLeS GUI

- Bundled with HercuLeS v1.0.0 (2013a) released on June 30
- Specify code generation, simulation and synthesis options
- Includes embedded results viewer



# Against competition

- New frontends, analyses and optimizations are easy to add
- Maps character I/O and malloc/free to efficient hardware
- Uses open IRs and formats (GIMPLE, NAC, Graphviz)
- Vendor and technology-independent HDL code generation
- Preliminary results against Vivado HLS 2013.1

| Benchmark               | Vivado HLS |            |                | HercuLeS   |            |               |
|-------------------------|------------|------------|----------------|------------|------------|---------------|
|                         | LUTs       | Regs       | Time (ns)      | LUTs       | Regs       | Time (ns)     |
| Array sum               | <b>102</b> | 132        | <b>26.5</b>    | 103        | <b>63</b>  | 73.3          |
| Bit reversal            | 67         | <b>39</b>  | 72.0           | <b>42</b>  | 40         | <b>11.6</b>   |
| Edge detection*         | <b>246</b> | <b>130</b> | 1636.3         | 680        | <b>361</b> | <b>1606.4</b> |
| Fibonacci series        | 138        | <b>131</b> | <b>60.2</b>    | <b>137</b> | 197        | 102.7         |
| FIR filter              | <b>102</b> | <b>52</b>  | <b>833.4</b>   | 217        | 140        | 2729.4        |
| Greatest common divisor | 210        | 98         | <b>35.2</b>    | <b>128</b> | <b>93</b>  | 75.9          |
| Cubic root approx.      | <b>239</b> | 207        | <b>260.6</b>   | 365        | <b>201</b> | 400.5         |
| Population count        | <b>45</b>  | <b>65</b>  | <b>19.4</b>    | 53         | 102        | 26.1          |
| Prime sieve*            | 525        | 595        | 6108.4         | <b>565</b> | <b>523</b> | <b>3869.5</b> |
| Sierpinski triangle     | <b>88</b>  | <b>163</b> | <b>11326.5</b> | 230        | 200        | 16224.9       |

# Summary and additional information

- ➦ HercuLeS is an extensible HLS environment for hardware and software engineers
- 📘 Named after the homonymous constellation and not the mighty but flawed demigod
- Commercial distribution: <http://www.ajaxcompilers.com>
- Technical details: <http://www.nkavvadias.com/hercules>
- Reference manual: <http://www.nkavvadias.com/hercules-reference-manual/hercules-refman.pdf>
- Feature matrix: <http://www.nkavvadias.com/hercules/hercules-feature-matrix.pdf>