FPGAs as manycore scientific coprocessors in high-level programming environments – Hastlayer

Zoltán Lehóczky, Benedek Farkas @ Lombiq

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Lombiq

be the hardware

Warning

Hastlayer is currently ~~experimental~~ in alpha stage!

logic expressed as software → logic expressed as hardware

…with FPGAs

- Field-programmable gate array
- Can behave as any logic circuit (within chip limits)

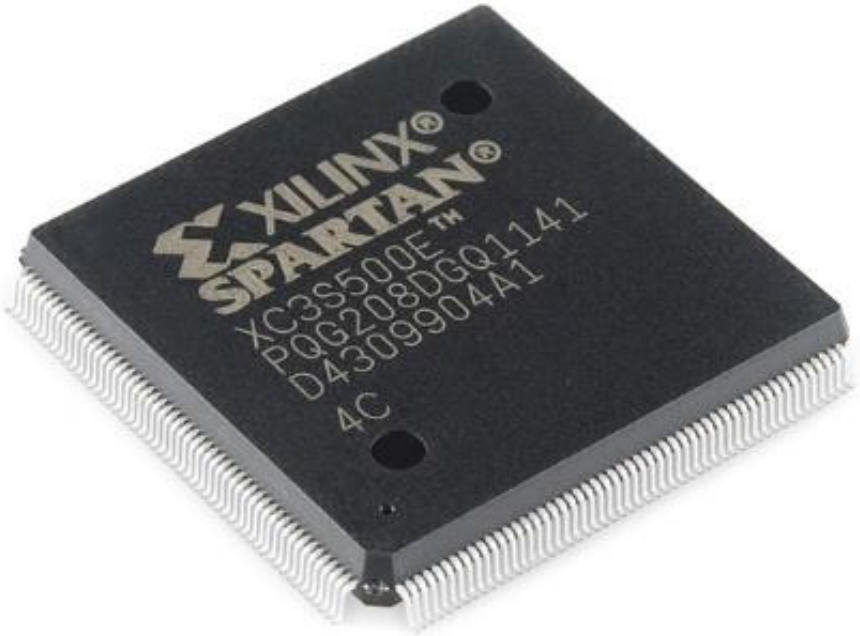

Image by SparkFun Electronics, Boulder, USA

.NET → VHDL → FPGA logic

Why is this useful?

- Significant performance increase for certain algorithms
- Less power consumption
- Still only software development

Let’s see a demo!

3D Kardar-Parisi-Zhang surface growth simulation

- Useful in semiconductor manufacturing to predict surface smoothness
- See Géza Ódor's presentation from last year or ask the Wigner guys

Let’s see a demo!

A (hopefully) revolutionary number format

Unum = Universal number

By John L. Gustafson,
author of *The End of Error*

Why?

- IEEE standards have fixed layout
  (hence the name "standard")
- Based on hardware restrictions
- Wasted bits
- I want problem-specific range and/or accuracy

What?

- Superset of IEEE 754
- Integer -> float -> unum
- Implemented in several languages
- MATLAB, Mathematica, Julia, C
  ... aaand .NET!

How?

- Define your own number layout
- Self-descriptive (utag)
- Honest about rounding
- No rounding and under/overflow
- Doesn't waste number space

Comparison: 16-bit float

- 1 sign
- 5 exponent
- 10 fraction bits (+ 1 implicit)

Comparison: Unum

- 1 sign bit
- "eSize" exponent bits
- "fSize" fraction bits (+ 1 implicit)
- 1 uncertainty bit
- "eSizeSize" exponent bits
- "fSizeSize" exponent bits

Unum initialization

- Configuration
  - eSize
  - fSize
- Environment
  - eSizeSize
  - fSizeSize

Benefits

- Fewer bits to describe the same information
  (e.g. no wasteful NaNs, only 2)
- You can optimize for integers
  - fSize = 2^eSize
  - Low fraction vs. high exponent with the same amount of bits
- Special number type specific to your problem
- Mathematica demo is self-aware for choice of environment
- Combination of points and ranges (ubit)

There’s more!

- Ubox: Multi-dimensional unum
- Ubound: Interval arithmetics (IEEE 1788)
- Unum 2.0

Next steps

- You can get a licence!
- Hastlayer Cloud
- FPGAs in every datacenter (Xeon + FPGA)

Thank you for your attention!

- guys@hastlayer.com
- https://hastlayer.com
- https://github.com/Lombiq/Hastlayer-Demo
- https://lombiq.com