Comparing functional Embedded Domain-Specific Languages for hardware description

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Introduction

Hardware design Domain-Specific Languages Hardware EDSLs

Analyzed EDS

Choice criteria Chosen EDSLs Evaluation criteria

Modeled Circuits

Choice ALU Memory bank CPU

Analysis of the EDSLs

ForSyDe Coquet



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Domain-Specific Languages

A computer language (turing-complete or *not*) targeting a *specific application domain.*

Example DSLs:

- SQL (database queries)
- CSS (document formatting)
- MATLAB (Matrix programming)
- VHDL (Hardware description)

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Domain-Specific Languages

A computer language (turing-complete or *not*) targeting a *specific application domain.*

Example DSLs:

- SQL (database queries)
- CSS (document formatting)
- MATLAB (Matrix programming)
- VHDL (Hardware description)

A DSL can also be *embedded* in a general-purpose language.

Example EDSLs:

- ▶ Boost.Proto (C++ / parser combinators)
- Diagrams (Haskell / programmatic drawing)
- Parsec (Haskell / parser combinators)

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Example of an EDSL: Parsec

A simple parser for a "Game of Life"-like input format:

```
dead, alive :: Parser Bool
dead = fmap (const False) (char '.')
alive = fmap (const True) (char '*')
line :: Parser [Bool]
line = many1 (dead <|> alive)
board :: Parser [[Bool]]
board = line 'endBy1' newline
parseBoardFromFile :: FilePath -> IO [[Bool]]
parseBoardFromFile filename = do
    result <- parseFromFile board filename
    return $ either (error . show) id result
```

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Hardware EDSLs

An EDSL used for hardware design-related tasks. Can encompass:

- ► Modelling / description
- Simulation (validation)
- Formal verification
- Synthesis to other (lower-level) languages

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Example of a hardware EDSL

Some Lava code...

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Choice criteria

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Chosen EDSLs

The language we chose to evaluate, with the respective host language, were:

- ► Lava (Haskell chalmers-lava dialect)
- ForSyDe (Haskell)
- Coquet (Coq)

Chosen EDSLs

ALU.

Coquet



Evaluation criteria

- Simulation
- Verification
- Genericity
- Depth of embedding
- Tool integration
- Extensibility

Evaluation criteria

ALU

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Modeled Circuits

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Choice criteria

- Not too simple, not too complex
- Familiar to any hardware designer
- ▶ Well-defined, available specification

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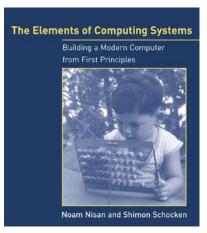
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Chosen circuits

We cherry-picked circuits from the book "Elements of Computing Systems", as they satisfied all of our demands.



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Figure: "Elements of Computing Systems" - Noam Nisan, Shimon Schocken, available at http://www.nand2tetris.org.

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ALU block diagram

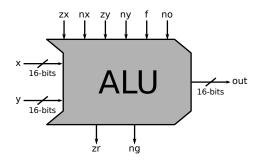


Figure: Input/Output ports of circuit 1, the ALU.

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Memory bank block diagram

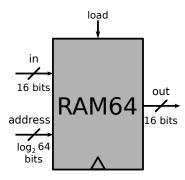


Figure: Input/Output ports of circuit 2, the RAM64 block.

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CPU block diagram

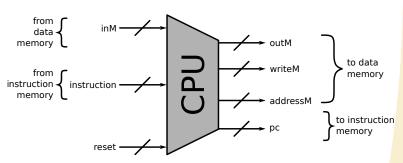


Figure: Input/Output ports of *circuit 3*, the *Hack* CPU.

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Thank you!

Questions?

