ForSyDe's embedded compiler

First development stage results.

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Outline

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General Goal Review

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  - Support all the synchronous process constructors in ForSyDe.
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- Let's see a simple example. Design a serial adder using components in 5 simple steps.

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1) Create a process function which adds one to its input

```
addOnef :: ProcFun (Int -> Int)
addOnef = $(newProcFun [d| addOnef :: Int -> Int
                           addOnef n = n + 1 |])
```

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2) Create a system function corresponding to the unit adder

```
addOneProc :: Signal Int -> Signal Int
addOneProc = mapSY "addOne" addOnef
```

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figures/SeqAddFour

3) Subsystem definition associated to the unit adder

```
addOneSysDef :: SysDef (Signal Int -> Signal Int)
addOneSysDef = $(newSysDef 'addOneProc ["in1"] ["out1"])
```

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figures/SeqAddFour

4) Create the main system function

```
addFour :: Signal Int -> Signal Int
addFour = $(instantiate "addOne3" 'addOneSysDef) .
          $(instantiate "addOne2" 'addOneSysDef) .
          $(instantiate "addOne1" 'addOneSysDef) .
          $(instantiate "addOne0" 'addOneSysDef)
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5) Finally, build the main system definition

```
addFourSys :: SysDef (Signal Int -> Signal Int)
addFourSys = $(newSysDef 'addFour ["in1"] ["out1"])
```

Design Flow Using Components

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Supporting any `Signal` type

- Challenge: support simulating signals of any type.
- How is it possible? `Typeable` and `Lift` constraints.

```
class Typeable a where
  typeOf :: a -> TypeRep

toDyn :: Typeable a => a -> Dynamic

class Lift t where
  lift :: t -> Q Exp
```

```
delaySY :: (Typeable a, Lift a) =>
             ProcId -> a -> Signal a ->  Signal a
```

- What about the instantiation boilerplate code?
  - GHC supports automatic derivation of `Typeable`
  - I Improved Igloo's Lift library (GHC 6.10 won't need it, i.e. `instance Data a => Lift a` will probably be included).

```
data LogicVal = High | Low deriving (Eq, Typeable)
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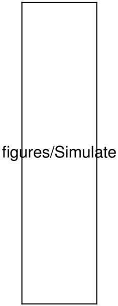
The simulation backend

- A new sequential simulation backend has been implemented



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- Completely usable but still not optimal:
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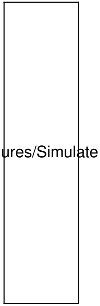

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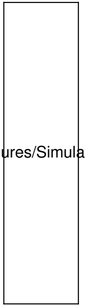

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Full support of the Synchronous Process Library

- All ForSyDe synchronous process and process constructors are supported in the frontend and the simulation backend.
  - Even polymorphic processes work (big thanks to Oleg Kisleyov for his help at haskell-cafe)
- The Equalizer was ported to the new compiler API and is correctly simulated
- The frontend already supports supplying identifiers for each process (detection of duplicates is not implemented yet)
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- By the time the library was rewritten, all modules were haddock-tagged.
- Thanks to the recent release of Haddock 2.0 (which is embedded in GHC), using Template Haskell is not a problem anymore.
- The package was cabalized. Configuring the package, building it, generating the documentation and installing it is as easy as typing:

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Improved VHDL backend

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  - Got the point of supporting components, `Bool`, `Int` signals, and only basic process constructors.
  - Currently working on a common API for translation backends.
- Reasons
  - Underestimated the task cost.
  - Time: stuck in various Template Haskell bugs and working in the frontend and the simulation backend.
  - Design problems still unsolved:
    - What types to support? How? i.e. Vectors, Floating point types.
    - How to support user-defined types? (i.e. typeclass constraints in process constructors could be an option).
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Accessing the external scope within ProcFuns

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```
$(newProcFun [d| filterer :: (a -> Bool) -> a -> AbstExt a
                 filterer pred val =
                   if pred val then Prst val else Abst  |])
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- New functions allow to pass parameters without loosing encapsulation:

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defArgVal :: (Lift a, Typeable a) => ProcFun (a -> b) -> a
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defArgPF :: ProcFun (a -> b) -> ProcFun a -> ProcFun b
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- Implementation of filterSY

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filterSY id pred = mapSY id (filterer `defArgPF` pred)
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    - Custom types?
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    - Process identifiers. Continue with current approach?
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