Monads are Not Scary!

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What are Monads?

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- · Monads are scary!
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 - in what situations is the monad pattern useful and
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What kind of libraries benefit from monads?

- Answer: Libraries that manipulate contextual information.
- Contextual information is implicit and the monad hides it.
- Examples:
 - Stateful libraries (mutuable arrays, I/O, ...)
 - Exception handling
 - Libraries using CPS (e.g., schedulers)
 - Libraries encapsulating search
 - Parser combinators



```
int compare_chars ()
{
   int a, b;

   a = getchar ();
   b = getchar ();
   return (a < b);
}</pre>
```



```
compare_chars =
  do {
    a <- getChar;
    b <- getChar;
    return (a < b);
}</pre>
```



```
compare_chars :: IO Bool
compare_chars =
  do {
    a <- getChar;
    b <- getChar;
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- "IO t": monad encapsulating the state of the world:
 - perform operations depending on external or internal state
 - perform operations changing external or internal state
 - when done, return a value of type t



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Hello World with Gtk2Hs

```
import Graphics.UI.Gtk
main :: IO ()
main =
  do {
    initGUI;
    window <- windowNew;
    button <- buttonNew;</pre>
    set window [ containerBorderWidth := 10,
                  containerChild := button ];
    set button [ buttonLabel := "Hello World" ];
    onClicked button (putStrLn "Hello World");
    onDestroy window mainQuit;
    widgetShowAll window;
    mainGUI;
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- onClicked :: Button -> IO () -> IO ()
- If you can write C programs, you can write programs in the IO monad



So, programming in the IO monad is like programming in C. Why bother?!?



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Advantage 1: Control side effects

Different signatures, different properties:

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noSideEffects :: Int -> Int
maybeSideEffects :: Int -> IO Int
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- Checked by the compiler, simplifies debugging
- Encapsulated internal state
- Required for concurrency!

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int compare_chars_bad ()
  {
    return (getchar () < getchar ());
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int compare_chars_bad ()
  {
    return (getchar () < getchar ()); // what order?
  }
    // same problem in ML</pre>
```



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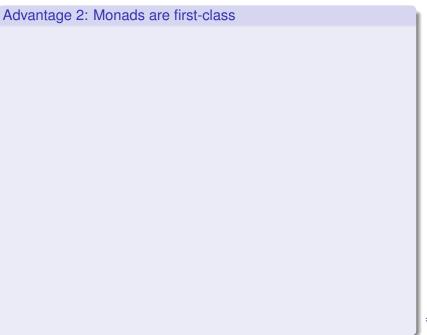
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Define your own monad! Here it gets slightly scary...

```
class Monad m where
  return :: a -> m a
  (>>=) :: m a -> (a -> m b) -> m b
instance Monad MyIO where ...
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The do notation is just syntactic sugar:

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do {
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- Redefine I0 to simplify debugging!
- foldl (>>) (return ()) Have fun!
 where m >> n = do {_ <- m; n}</pre>



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- External state: external to the application (hard disks, networks, ...); can only be manupilated by side effects
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- State transformer monad



```
data ST s a
instance Monad ST
data STRef s a
```

readSTRef :: STRef s a -> ST s a

writeSTRef :: STRef s a -> a -> ST () a

runST :: (forall s. ST s a) -> a



Different Categories of Monads

Monads classified:

- State transformer monad
- Reader monad & writer monad
- Exception monad
- CPS monad
- Indeterminism monad
- Time-runs-backwards monad
- List monad
- Strictness monad
- Identity monad
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- There are also monad transformers
- Parser monad Hello André!

