Rhine, FRP with type-level clocks

Functional Reactive Programming for Zurihac '24

Manuel Bärenz

June 8, 2024

Functional Reactive Programming with Rhine

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- I'm Manuel Bärenz (he/him)

Plan for this session

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- 14:10 You'll start on the UI track, or on your own little app, I'll come around and answer questions

Let me tell you a tale...

...but don't worry!

You don't need to memorise everything. Lean back & relax :)

About Functional Reactive Programming

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- *When* do computations & effects happen?

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- Accidental synchronisation becomes a type error
- Framework to answer the question "*When* do computations & effects happen?"

Rhine concepts

Clock types and values

```haskell
class Clock m cl where
  type Time cl -- The type of timestamps
  type Tag cl -- Additional info about the tick
  ...

-- Ticks every 10 milliseconds.
waitClock :: Millisecond 10
waitClock = ...
instance Clock IO (Millisecond 10) where ...

-- Ticks for every line entered on stdin. (An "event")
data StdinClock = StdinClock
instance Clock IO StdinClock where
  type Tag StdinClock = Text
  ...
```

Rhine concepts

Running example

github.com/turion/rhine/blob/master/rhine-examples/src/Ball.hs

Clocked signal functions (`ClSF`)

```haskell
type Ball = (Double, Double, Double)
type BallVel = (Double, Double, Double)

startVel :: ClSF IO StdinClock () BallVel
startVel = arrMCl $ const $ do
  velX <- randomRIO (-10, 10)
  velY <- randomRIO (-10, 10)
  velZ <- randomRIO (3, 10)
  return (velX, velY, velZ)
```

Rhine concepts

Behaviours: Clock-independent signal functions

```
freeFall :: (Monad m) => BallVel ->
  BehaviourF m UTCTime () Ball
freeFall v0 =
  arr (const (0, 0, -9.81))
    >>> integralFrom v0
    >>> integral
```

Arrow syntax

```
height :: (Monad m) => BallVel ->
  BehaviourF m UTCTime () Double
height v0 = proc _ -> do
  pos <- freeFall v0 -< ()
  let (_, _, height) = pos
  returnA -< height
```

Rhine concepts

```
throwMaybe :: (Monad m) =>
  ClSF (ExceptT e m) cl (Maybe e) (Maybe a)
```

Throwing exceptions

```
falling :: (Monad m) => BallVel -> ClSF (ExceptT () m)
  (Millisecond 10) (Maybe BallVel) Ball
falling v0 = proc _ -> do
  pos <- freeFall v0 -< ()
  let (_, _, height) = pos
  throwMaybe -< guard $ height < 0
  returnA -< pos

waiting :: (Monad m) => ClSF (ExceptT BallVel m)
  (Millisecond 10) (Maybe BallVel) Ball
waiting = throwMaybe >>> arr (const zeroVector)
```

Rhine concepts

```
data ClSFExcept clock input output monad exception
```

Handling exceptions

```
ballModes :: ClSFExcept (Millisecond 10)
  (Maybe BallVel) Ball IO void
ballModes = do
  v0 <- try waiting
  once_ $ putStrLn "Catch!"
  try $ falling v0
  once_ $ putStrLn "Caught!"
  ballModes

ball :: ClSF IO (Millisecond 10) (Maybe BallVel) Ball
ball = safely ballModes
```

Rhine concepts

Top level programs: `Rhine`

```
startVelRh :: Rhine IO StdinClock () BallVel
startVelRh = startVel @@ StdinClock

resample :: ResamplingBuffer IO
  StdinClock (Millisecond 10) BallVel (Maybe BallVel)
resample = fifoUnbounded

ballRh :: Rhine IO (Millisecond 10) (Maybe BallVel) Ball
ballRh = ball @@ waitClock

mainRhine :: Rhine IO
  (SeqClock StdinClock (Millisecond 10)) () ()
mainRhine = startVelRh >-- resample --> ballRh

main = flow mainRhine
```

Basic track (until 14:00)

Let's get it off the ground!

```
git clone git@github.com:turion/rhine-koans.git
cabal test basic-1-1-hello-rhine-test
cabal run basic-1-1-hello-rhine
```

Slides

github.com/turion/rhine-koans/blob/main/presentation/presentation.pdf

Ask me anything :)

Manuel (he/him), turion on Discord/Discourse/Github/..., turion@types.pl on Mastodon

Advanced track

Let's dive in!

```
cabal test ui-1-gloss-1-circle-test
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- Websocket clock: `https://hackage.haskell.org/package/wuss`

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- Challenge: Rhine entry in https://github.com/gelisam/frp-zoo