Frege

purely functional programming on the JVM

JFocus 2016

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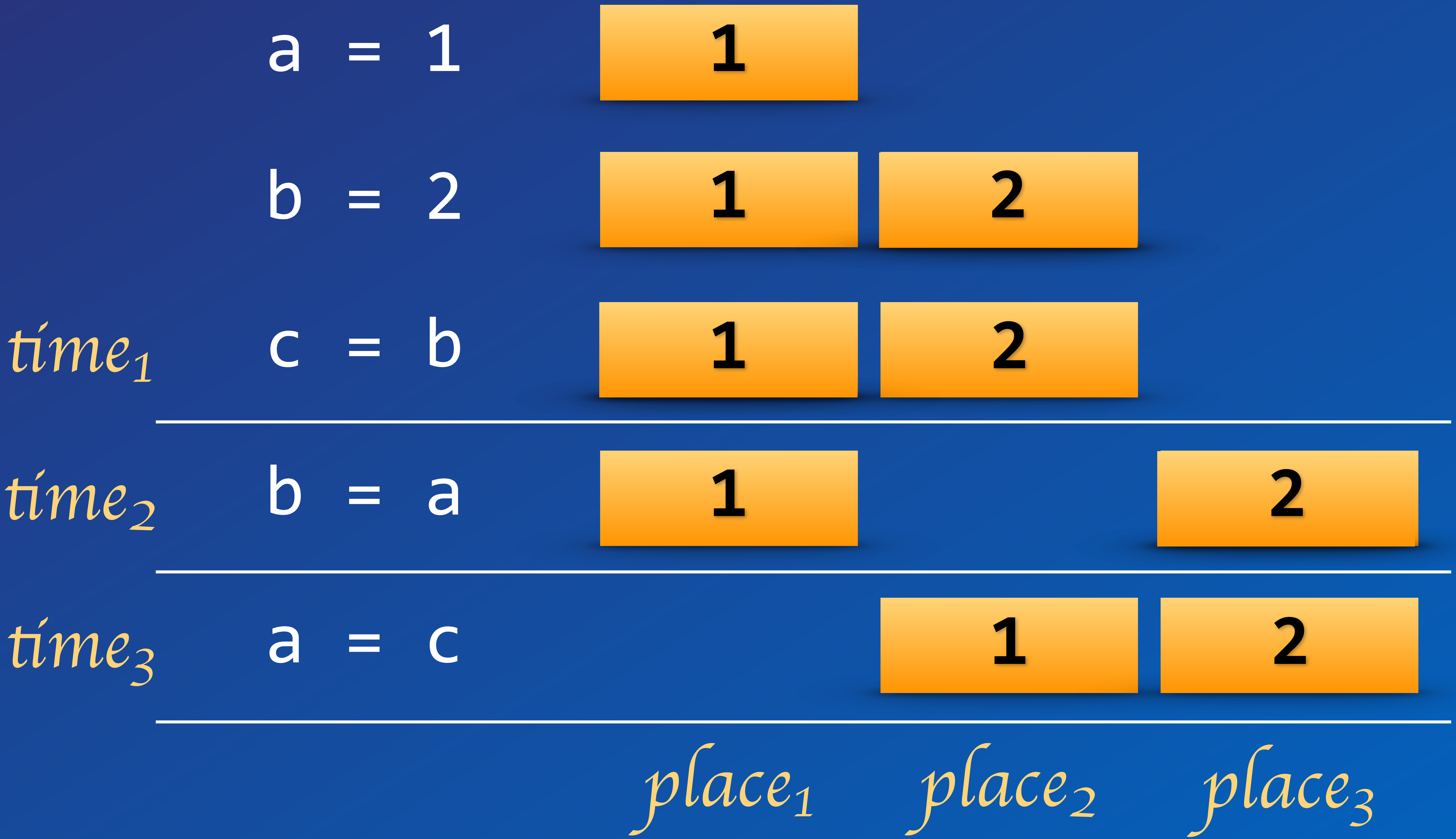
canoo

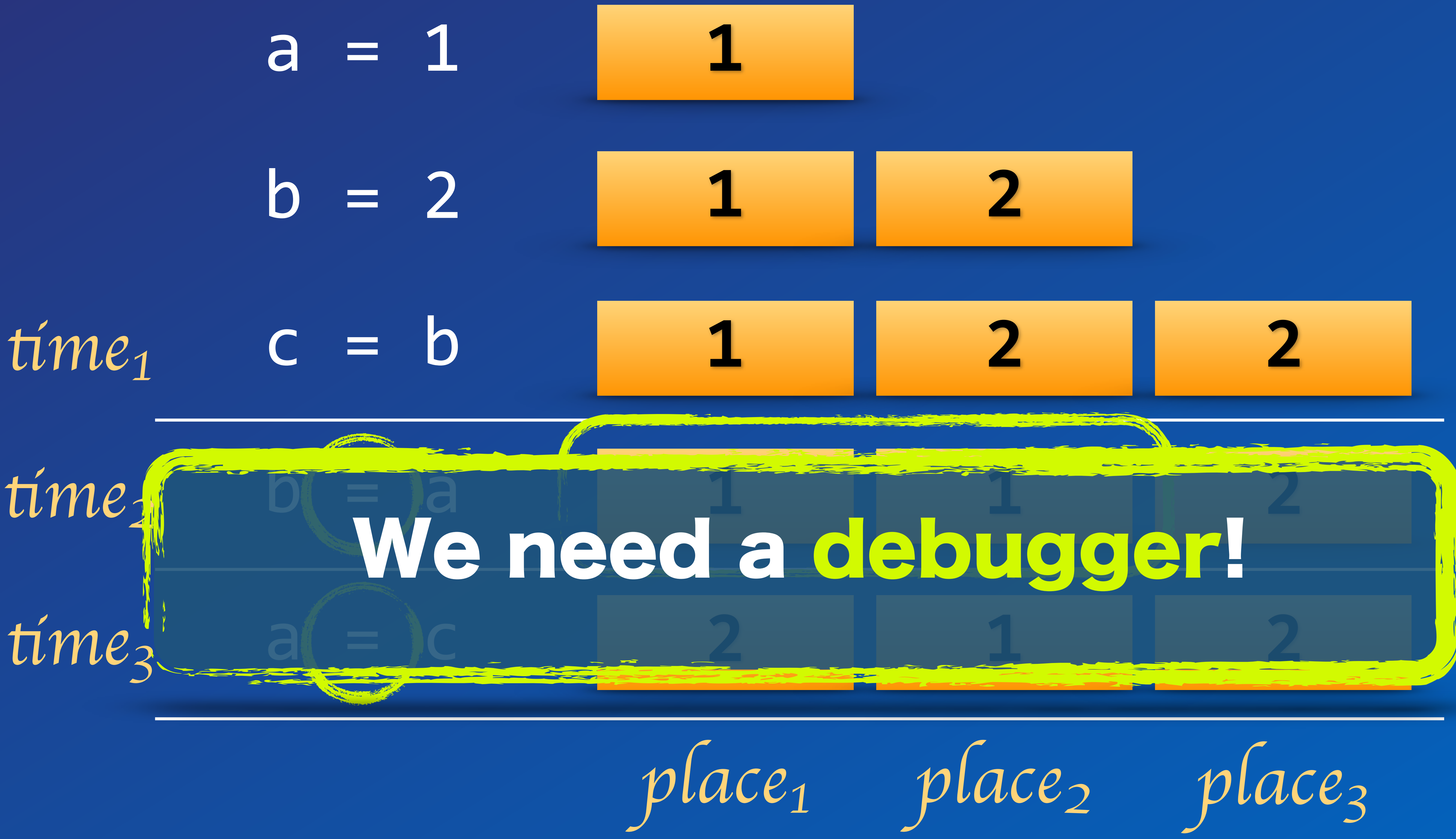
mittie

Why do we care?



```
a = 1
b = 2
c = b
b = a
a = c
```

Operational Reasoning

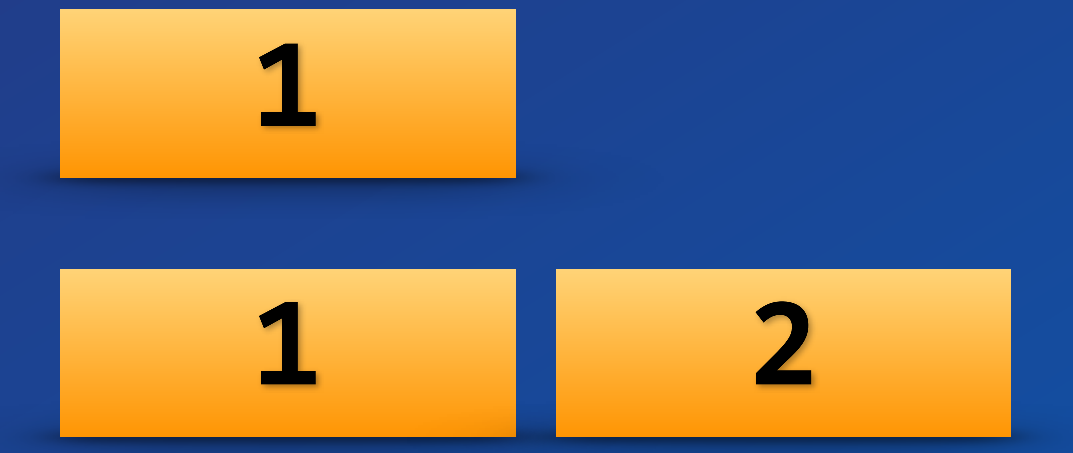


```
a = 1
b = 2
c = b
b = a
a = c
```

We need a debugger!

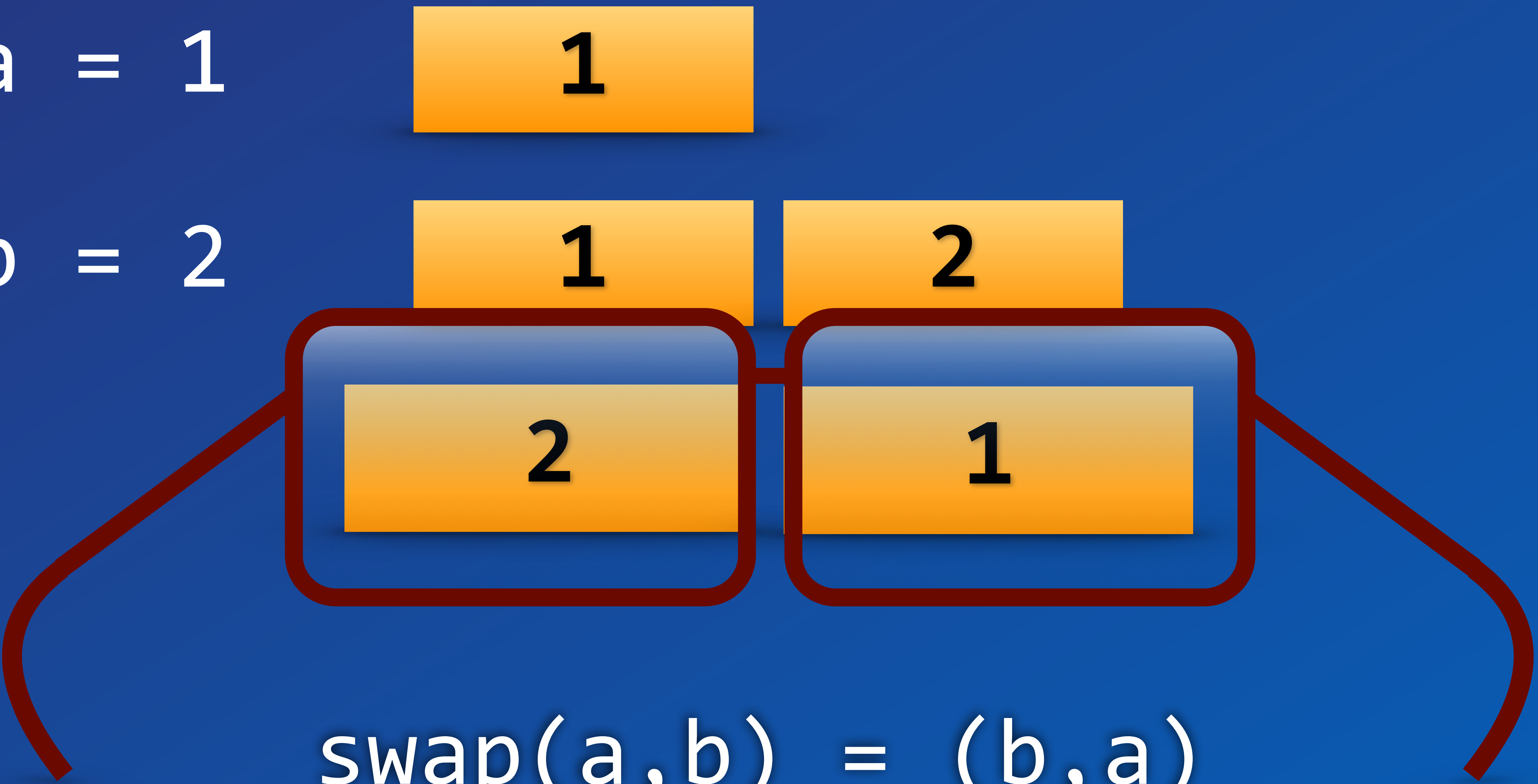
Using functions

```
a = 1
b = 2
```



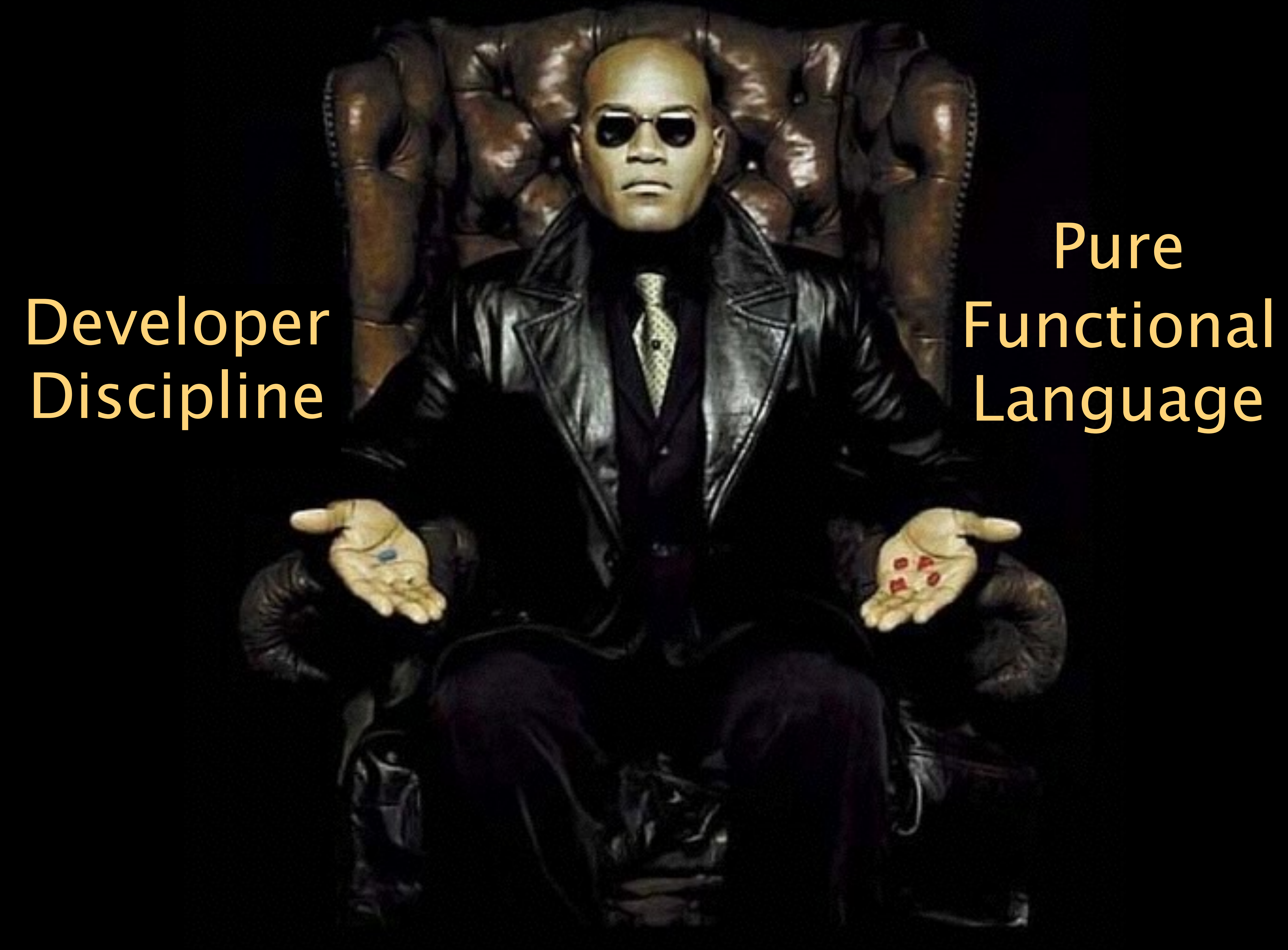
Using functions

```
a = 1
b = 2
```



```
swap(a,b) = (b,a)
```

Let’s just program without assignments or statements!


Developer Discipline
Pure Functional Language

Online REPL

try.frege-lang.org

Define a Function

```
frege> times a b = a * b

frege> times 2 3

6

frege> :type times

Num α => α -> α -> α
```

Define a Function

```
frege> times a b = a * b
```

no types declared

```
frege>(times 2)3
6
```

function appl. left associative

no comma

```
frege> :type times
Num α => α ->(α -> α)
```

typeclass constraint

only 1 parameter!

return type is a function!

thumb: „two params of same numeric type returning that type“

Reference a Function

```
frege> twotimes    = times 2

frege> twotimes 3

6

frege> :t twotimes

Int -> Int
```

Reference a Function

```
frege> twotimes x = times 2 x

frege> twotimes 3

6

frege> :t twotimes

Int -> Int
```

No second arg!

„Currying“, „schönfinkeling“, or „partial function application“. Concept invented by Gottlob Frege.

inferred types are more specific

Function Composition

```
frege> six x =  twotimes (threetimes x)

frege> six x = (twotimes . threetimes)x

frege> six   =  twotimes . threetimes

frege> six 2

12
```

Function Composition

$f(g(x))$

$(f \circ g)\ x$

$f \circ g$

```
fr                 =  twotimes (threetimes x)

fr                 = (twotimes . threetimes)x

fr                 =  twotimes . threetimes

frege> six 2

12
```

Pure Functions

Java

```
T foo(Pair<T,U> p) {…}
```

What could possibly happen?

Frege

```
foo :: (α,β) -> α
```

What could possibly happen?

Pure Functions

Java

```
T foo(Pair<T,U> p) {…}
```

Everything!
State changes,
file or db access,
missile launch,…

Frege

```
foo :: (α,β) -> α
```

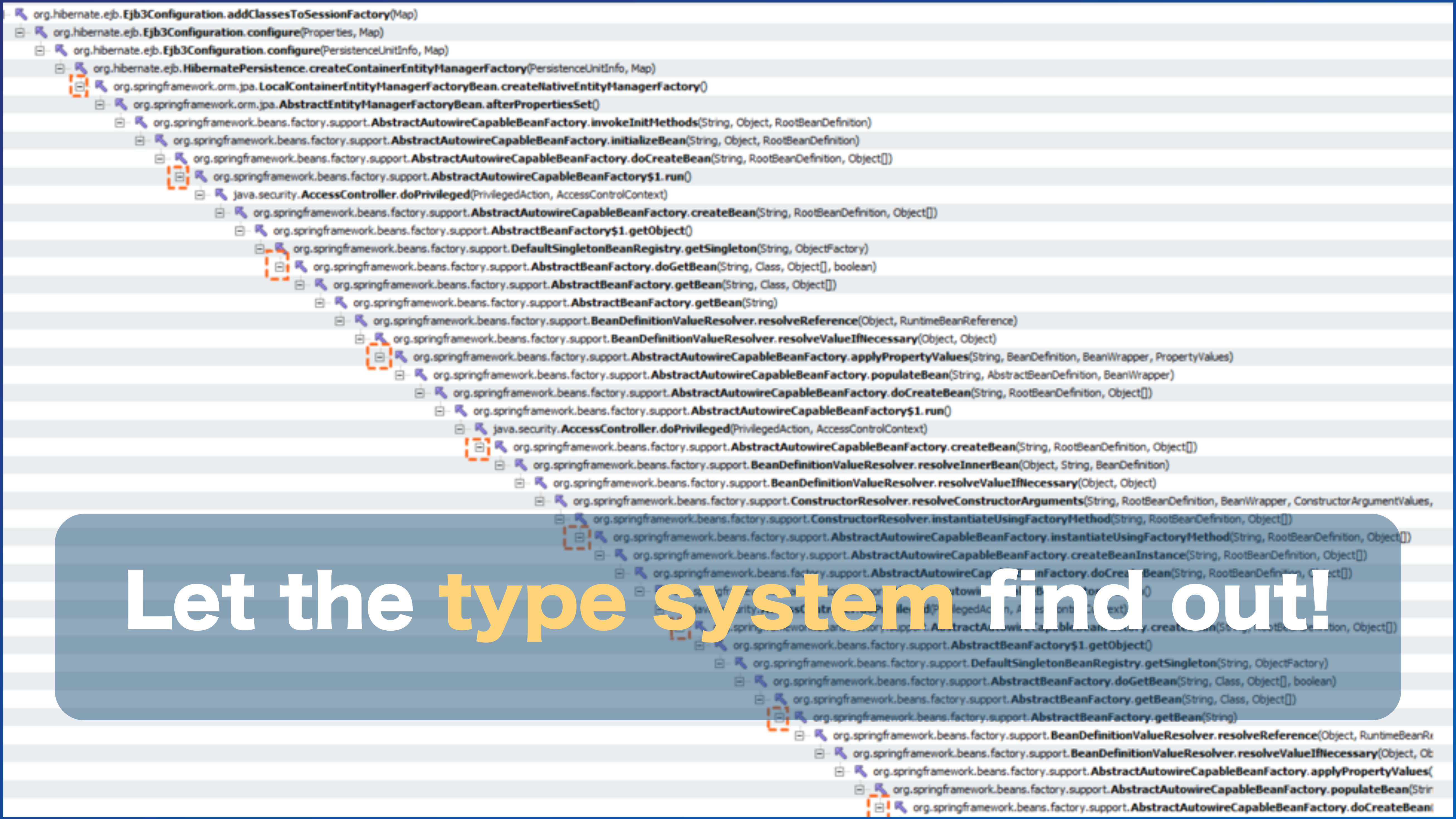
a is returned

Pure Functions

can be cached (memoized)
can be evaluated lazily
can be evaluated in advance
can be evaluated concurrently
can be eliminated
    in common subexpressions

can be optimized

Is my method pure?



```
org.hibernate.ejb.Ejb3Configuration.addClassesToSessionFactory(Map)
 org.hibernate.ejb.Ejb3Configuration.configure(Properties, Map)
  org.hibernate.ejb.Ejb3Configuration.configure(PersistenceUnitInfo, Map)
   org.hibernate.ejb.HibernatePersistence.createContainerEntityManagerFactory(PersistenceUnitInfo, Map)
    org.springframework.orm.jpa.LocalContainerEntityManagerFactoryBean.createNativeEntityManagerFactory()
     org.springframework.orm.jpa.AbstractEntityManagerFactoryBean.afterPropertiesSet()
      org.springframework.beans.factory.support.AbstractAutowireCapableBeanFactory.invokeInitMethods(String, Object, RootBeanDefinition)
       org.springframework.beans.factory.support.AbstractAutowireCapableBeanFactory.initializeBean(String, Object, RootBeanDefinition)
        org.springframework.beans.factory.support.AbstractAutowireCapableBeanFactory.doCreateBean(String, RootBeanDefinition, Object[])
         org.springframework.beans.factory.support.AbstractAutowireCapableBeanFactory$1.run()
          java.security.AccessController.doPrivileged(PrivilegedAction, AccessControlContext)
           org.springframework.beans.factory.support.AbstractAutowireCapableBeanFactory.createBean(String, RootBeanDefinition, Object[])
            org.springframework.beans.factory.support.AbstractBeanFactory$1.getObject()
             org.springframework.beans.factory.support.DefaultSingletonBeanRegistry.getSingleton(String, ObjectFactory)
              org.springframework.beans.factory.support.AbstractBeanFactory.doGetBean(String, Class, Object[], boolean)
               org.springframework.beans.factory.support.AbstractBeanFactory.getBean(String, Class, Object[])
                org.springframework.beans.factory.support.AbstractBeanFactory.getBean(String)
                 org.springframework.beans.factory.support.BeanDefinitionValueResolver.resolveReference(Object, RuntimeBeanReference)
                  org.springframework.beans.factory.support.BeanDefinitionValueResolver.resolveValueIfNecessary(Object, Object)
                   org.springframework.beans.factory.support.AbstractAutowireCapableBeanFactory.applyPropertyValues(String, BeanDefinition, BeanWrapper, PropertyValues)
                    org.springframework.beans.factory.support.AbstractAutowireCapableBeanFactory.populateBean(String, AbstractBeanDefinition, BeanWrapper)
                     org.springframework.beans.factory.support.AbstractAutowireCapableBeanFactory.doCreateBean(String, RootBeanDefinition, Object[])
                      org.springframework.beans.factory.support.AbstractAutowireCapableBeanFactory$1.run()
                       java.security.AccessController.doPrivileged(PrivilegedAction, AccessControlContext)
                        org.springframework.beans.factory.support.AbstractAutowireCapableBeanFactory.createBean(String, RootBeanDefinition, Object[])
                         org.springframework.beans.factory.support.BeanDefinitionValueResolver.resolveInnerBean(Object, String, BeanDefinition)
                          org.springframework.beans.factory.support.BeanDefinitionValueResolver.resolveValueIfNecessary(Object, Object)
                           org.springframework.beans.factory.support.ConstructorResolver.resolveConstructorArguments(String, RootBeanDefinition, BeanWrapper, ConstructorArgumentValues,
                            org.springframework.beans.factory.support.ConstructorResolver.instantiateUsingFactoryMethod(String, RootBeanDefinition, Object[])
                             org.springframework.beans.factory.support.AbstractAutowireCapableBeanFactory.instantiateUsingFactoryMethod(String, RootBeanDefinition, Object[])
                              org.springframework.beans.factory.support.AbstractAutowireCapableBeanFactory.createBeanInstance(String, RootBeanDefinition, Object[])
                               org.springframework.beans.factory.support.AbstractAutowireCapableBeanFactory.doCreateBean(String, RootBeanDefinition, Object[])
                                org.springframework.beans.factory.support.AbstractAutowireCapableBeanFactory$1.run()
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                                  org.springframework.beans.factory.support.AbstractAutowireCapableBeanFactory.createBean(String, RootBeanDefinition, Object[])
                                   org.springframework.beans.factory.support.AbstractBeanFactory$1.getObject()
                                    org.springframework.beans.factory.support.DefaultSingletonBeanRegistry.getSingleton(String, ObjectFactory)
                                     org.springframework.beans.factory.support.AbstractBeanFactory.doGetBean(String, Class, Object[], boolean)
                                      org.springframework.beans.factory.support.AbstractBeanFactory.getBean(String, Class, Object[])
                                       org.springframework.beans.factory.support.AbstractBeanFactory.getBean(String)
                                        org.springframework.beans.factory.support.BeanDefinitionValueResolver.resolveReference(Object, RuntimeBeanR
                                         org.springframework.beans.factory.support.BeanDefinitionValueResolver.resolveValueIfNecessary(Object, Ob
                                          org.springframework.beans.factory.support.AbstractAutowireCapableBeanFactory.applyPropertyValues(
                                           org.springframework.beans.factory.support.AbstractAutowireCapableBeanFactory.populateBean(Strin
                                            org.springframework.beans.factory.support.AbstractAutowireCapableBeanFactory.doCreateBean
```

Let the type system find out!

Java Interoperability

Do not mix
OO and FP,

combine them!

Java -> Frege

Frege compiles Haskell to Java source and byte code.

Just call that.

You can get help by using the :java command in the REPL.

Frege -> Java

```
pure native encode java.net.URLEncoder.encode :: String -> String
encode “Dierk König“
```

even Java can be pure

```
native millis java.lang.System.currentTimeMillis :: () -> IO Long
millis ()
millis ()
past = millis () - 1000
```

This is a key distinction between Frege and other JVM languages!

Does not compile!

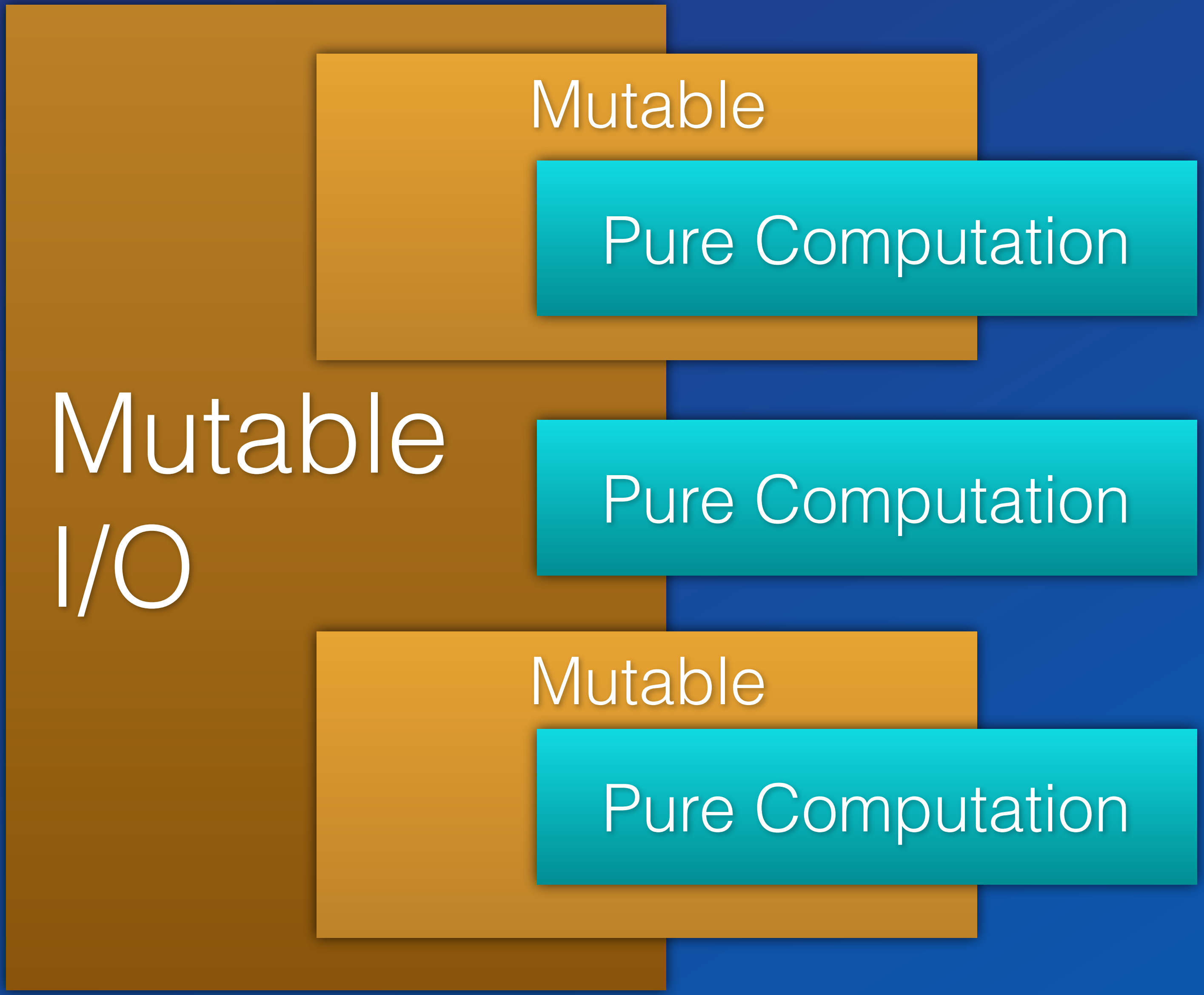
Frege

allows calling Java
but never unprotected!

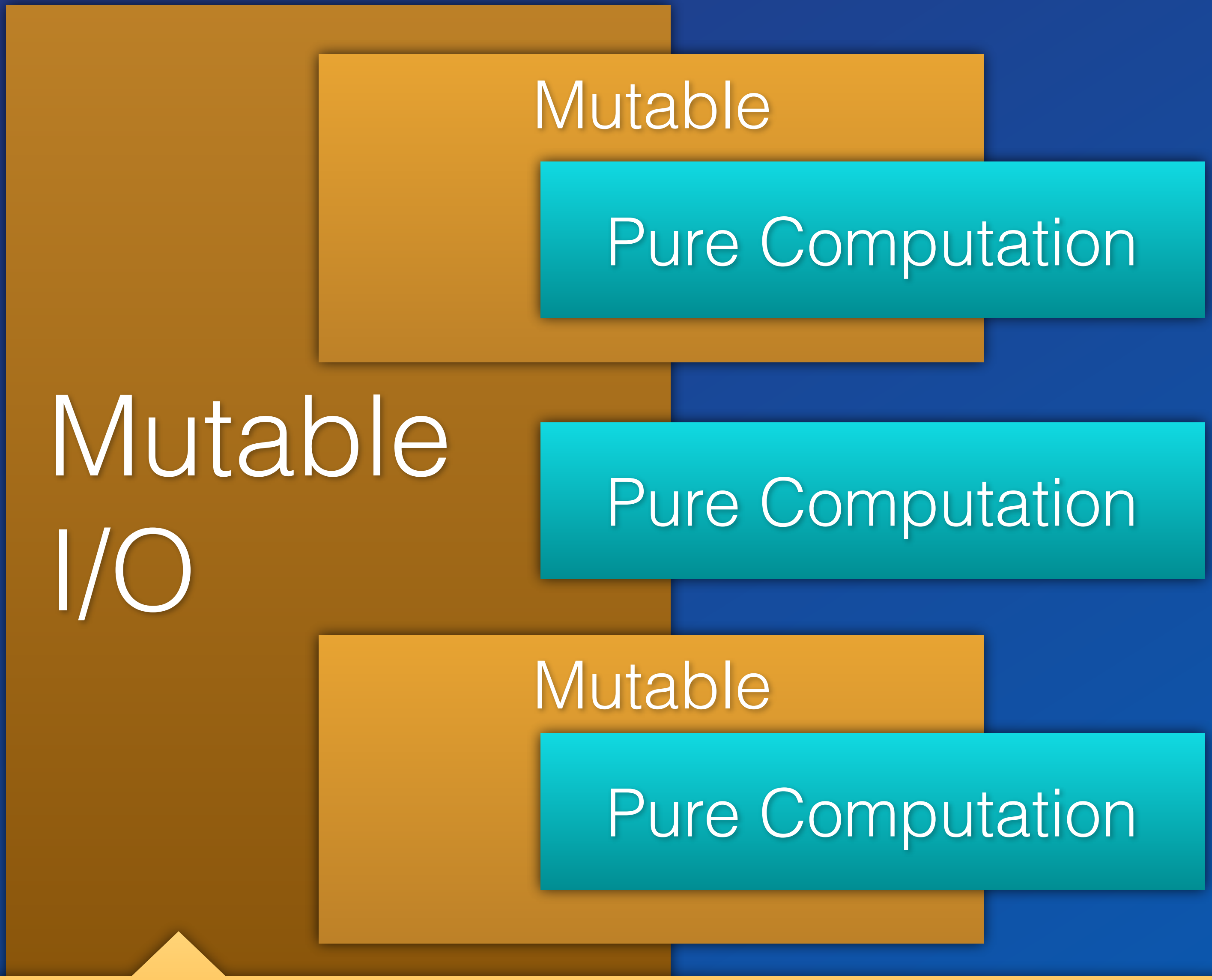
is explicit about effects
just like Haskell

Prerequisite to safe concurrency and deterministic parallelism!

Keep the mess out!



Keep the mess out!



Thread-safe by design! Checked by compiler

Ok, these are Monads. Be brave. Think of them as contexts that the type system propagates and makes un-escapable.

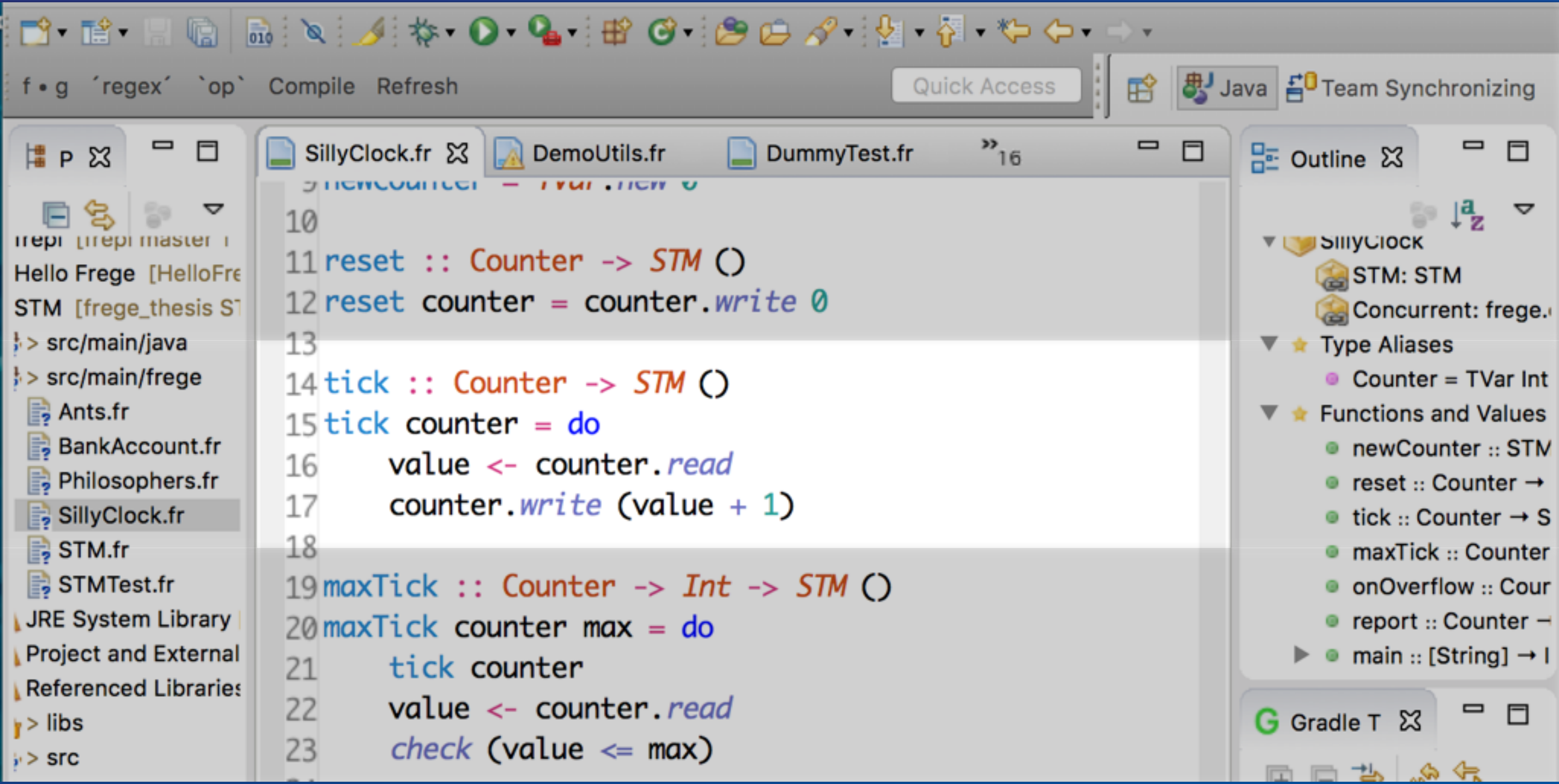
Type System

Global type inference

More safety and less work for the programmer

You don't need to specify any types at all!
But sometimes you do for clarity.

Pure Transactions

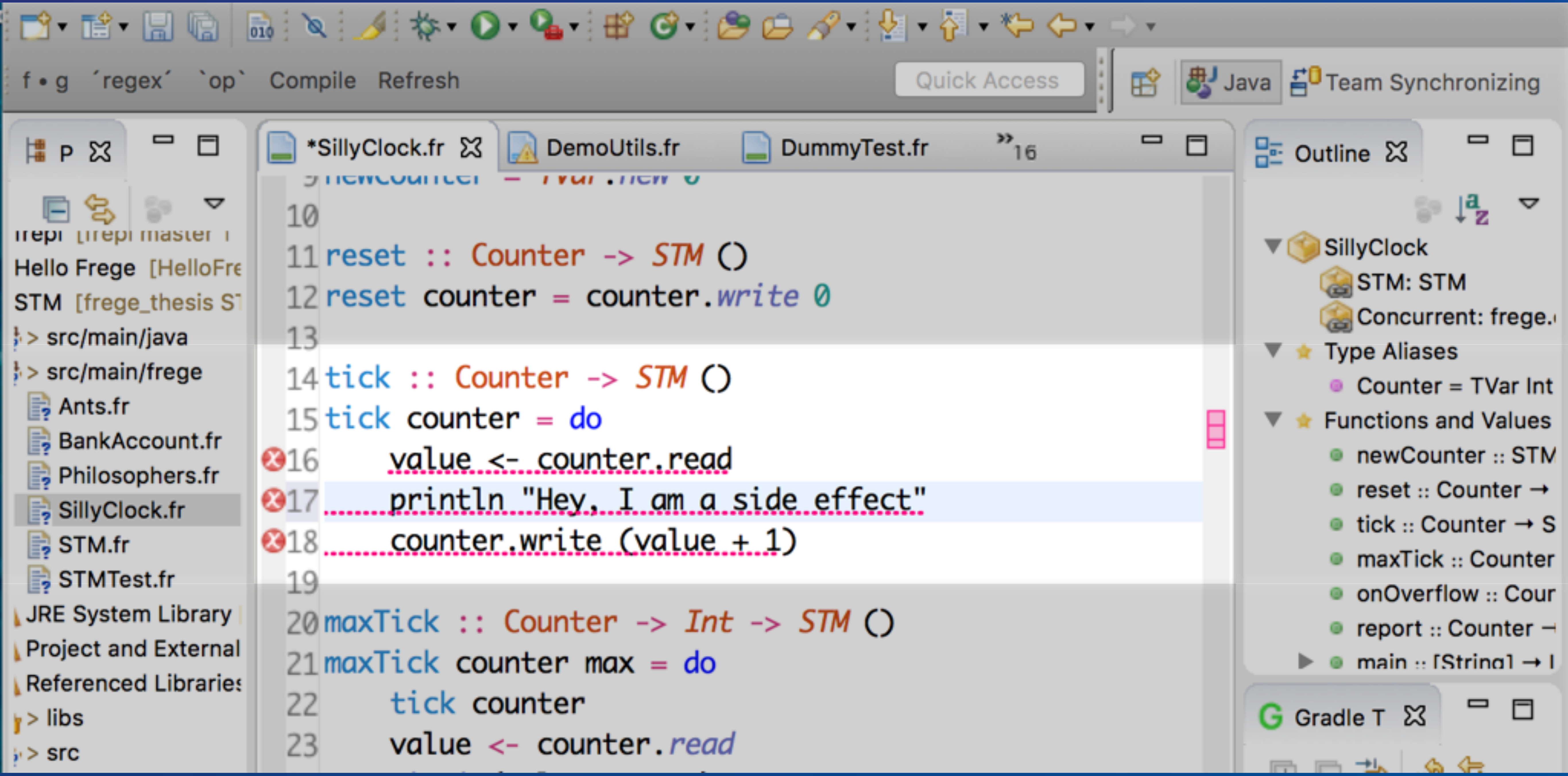


```
reset :: Counter -> STM ()
reset counter = counter.write 0

tick :: Counter -> STM ()
tick counter = do
    value <- counter.read
    counter.write (value + 1)

maxTick :: Counter -> Int -> STM ()
maxTick counter max = do
    tick counter
    value <- counter.read
    check (value <= max)
```

Type inference FTW



```
reset :: Counter -> STM ()
reset counter = counter.write 0

tick :: Counter -> STM ()
tick counter = do
    value <- counter.read
    println "Hey, I am a side effect"
    counter.write (value + 1)

maxTick :: Counter -> Int -> STM ()
maxTick counter max = do
    tick counter
    value <- counter.read
```

Fizzbuzz

http://c2.com/cgi/wiki?FizzBuzzTest

https://dierk.gitbooks.io/fregegoodness/

chapter 8 „FizzBuzz“

Fizzbuzz Imperative

```
public class FizzBuzz{
  public static void main(String[] args){
    for(int i= 1; i <= 100; i++){
      if(i % 15 == 0{
        System.out.println(„FizzBuzz");
      }else if(i % 3 == 0){
        System.out.println("Fizz");
      }else if(i % 5 == 0){
        System.out.println("Buzz");
      }else{
        System.out.println(i);
} } } }
```

Fizzbuzz Logical

```
fizzes   = cycle   ["", "", "fizz"]
buzzes   = cycle   ["", "", "", "", "buzz"]
pattern  = zipWith (++) fizzes buzzes
numbers  = map     show [1..]
fizzbuzz = zipWith max pattern numbers

main _   = for (take 100 fizzbuzz) println
```

Fizzbuzz Comparison

	Imperative	**Logical**
Conditionals	4	0
Operators	7	1
Nesting level	3	0
Sequencing	sensitive	transparent
Maintainability	- - -	+
Incremental development	-	+++

Unique in Frege

Global type inference *(requires purity)*

Purity by default

  effects are explicit in the type system

Type-safe concurrency & parallelism

Laziness by default

Values are always immutable

Guarantees extend into Java calls

Why Frege

Robustness under parallel execution
Robustness under composition
Robustness under increments
Robustness under refactoring

Enables local and equational reasoning

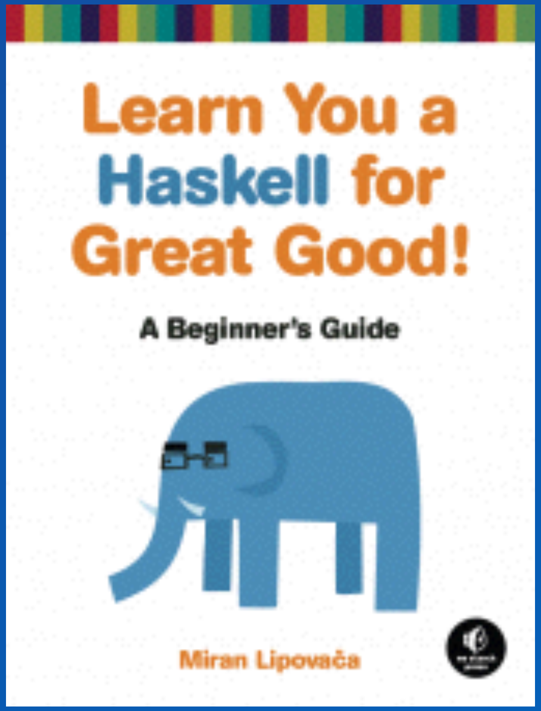
Best way to learn FP

Why Frege

it is just a pleasure to work with

How?

http://www.frege-lang.org
@fregelang
stackoverflow „frege“ tag
edX FP101 MOOC



Please give feedback!

Dierk König

canoo

mittie

FGA

Language level is Haskell Report 2010.
Yes, performance is roughly ~ Java.
Yes, the compiler is reasonably fast.
Yes, we have an Eclipse Plugin.
Yes, Maven/Gradle/etc. integration.
Yes, we have HAMT (aka HashMap).
Yes, we have QuickCheck (+shrinking)
Yes, STM is almost finished.

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