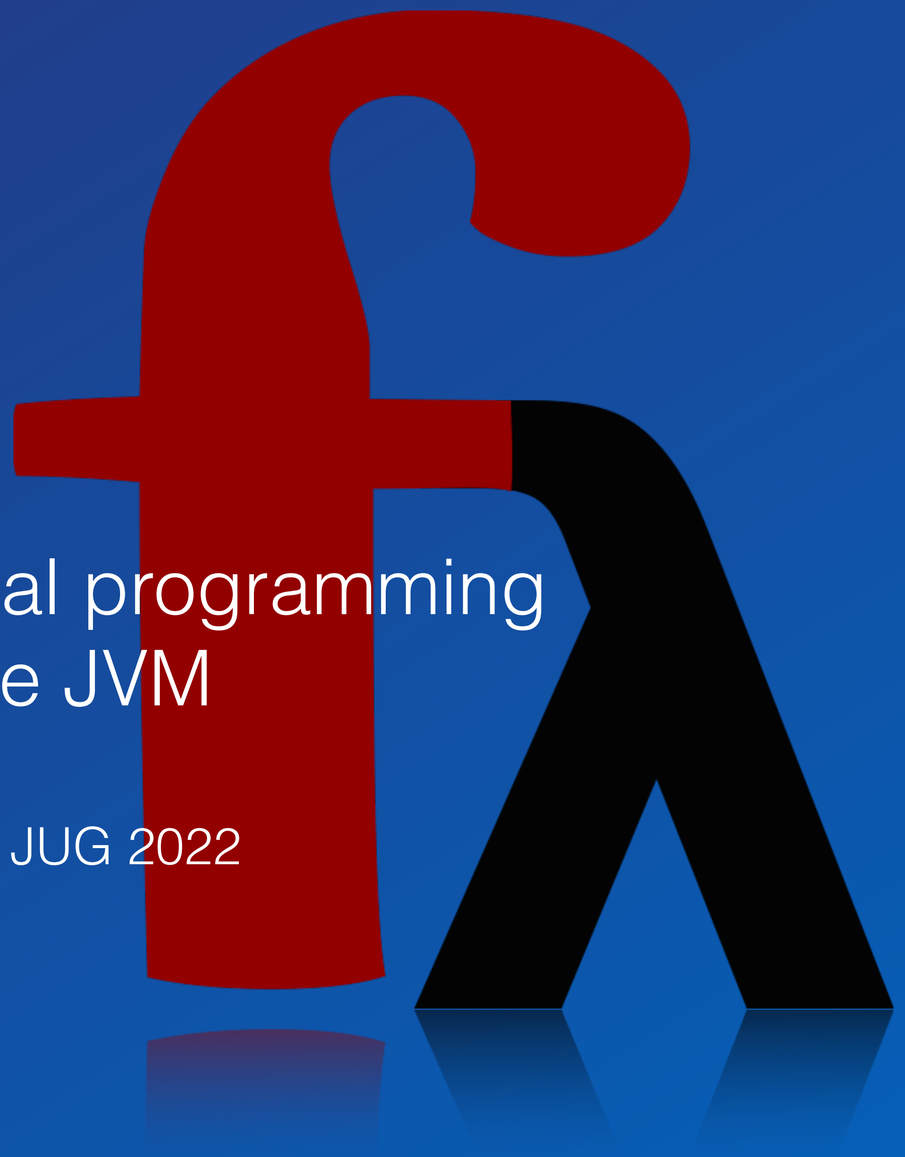
Frege

purely functional programming on the JVM

St. Louis JUG 2022



Prof. Dierk König

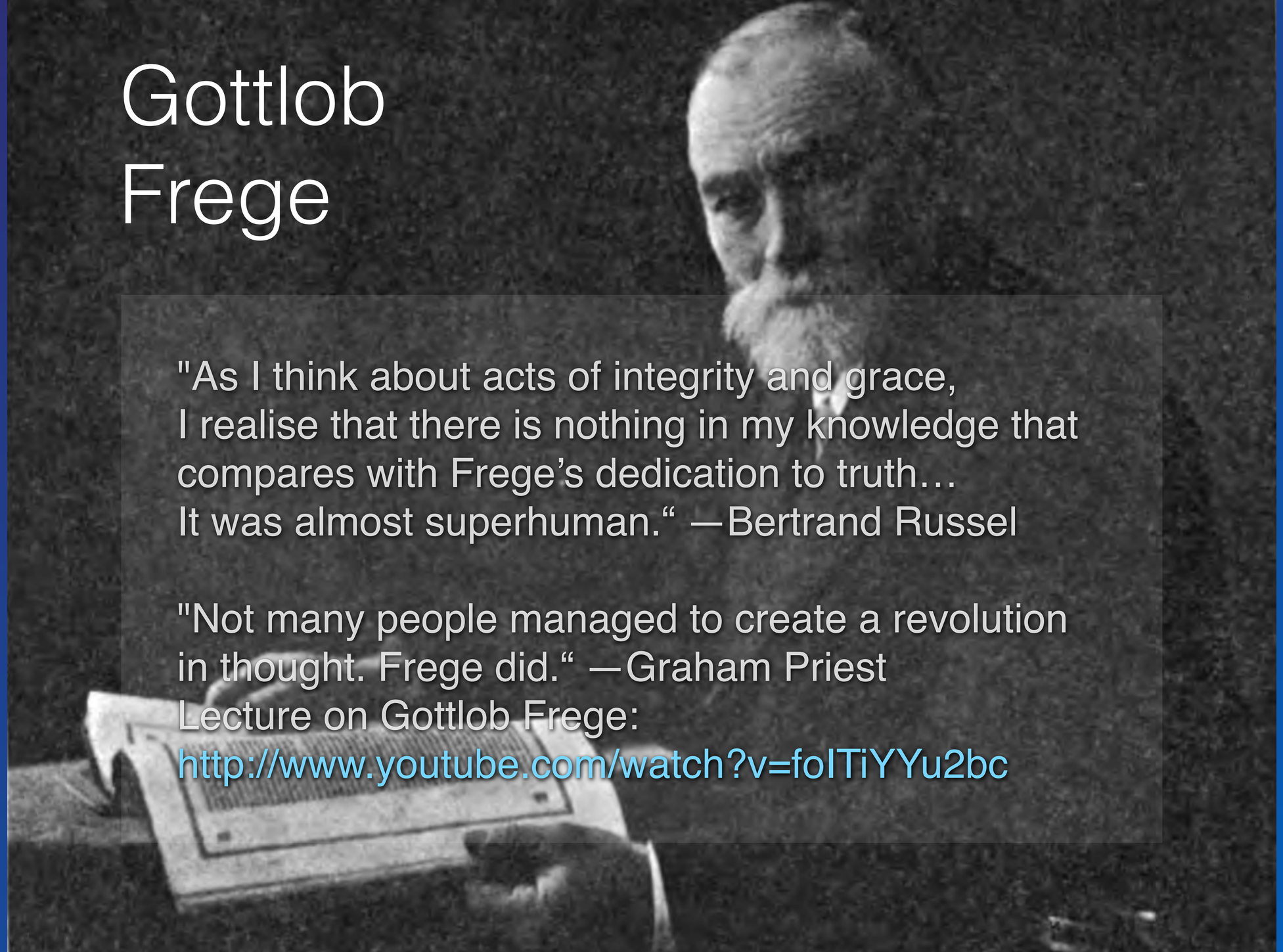
Professor at FHNW

Fellow at Karakun

@mittie

frege-lang.org

Gottlob Frege

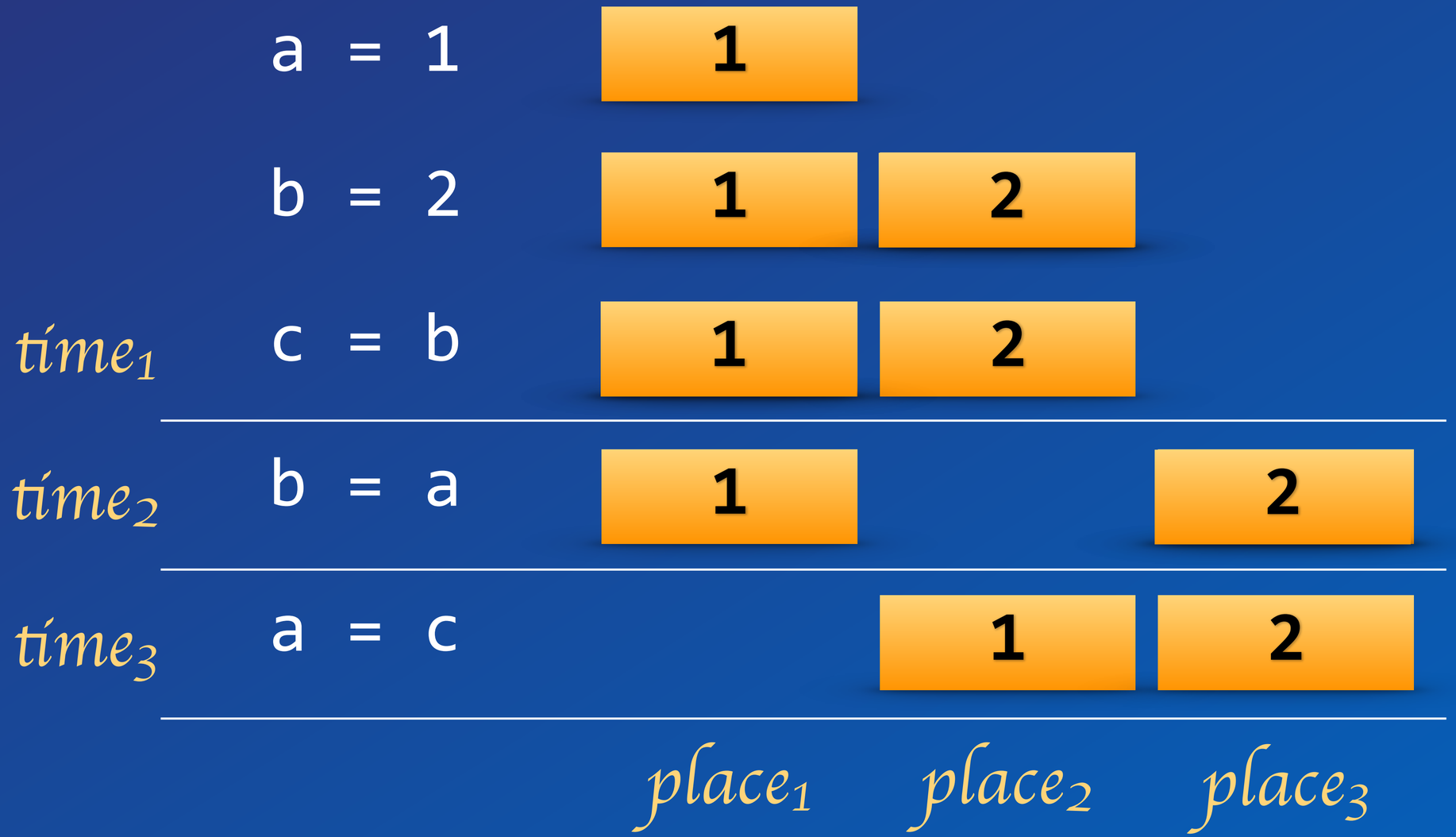


"As I think about acts of integrity and grace,
I realise that there is nothing in my knowledge that
compares with Frege's dedication to truth…
It was almost superhuman." —Bertrand Russel

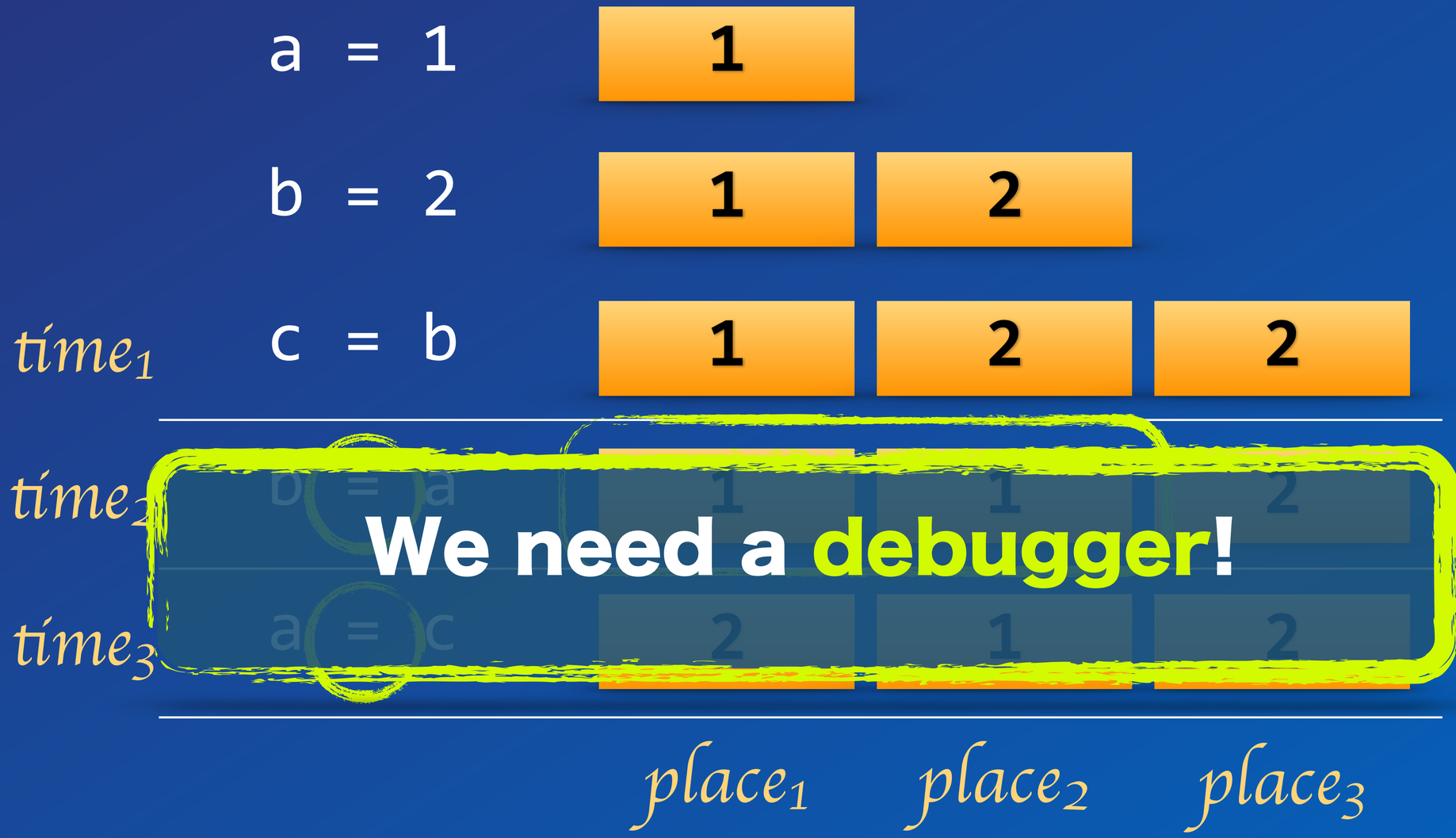
"Not many people managed to create a revolution
in thought. Frege did." —Graham Priest
Lecture on Gottlob Frege:
http://www.youtube.com/watch?v=foITiYYu2bc

Dreaming of code

Why do we care?



Operational Reasoning



Using functions

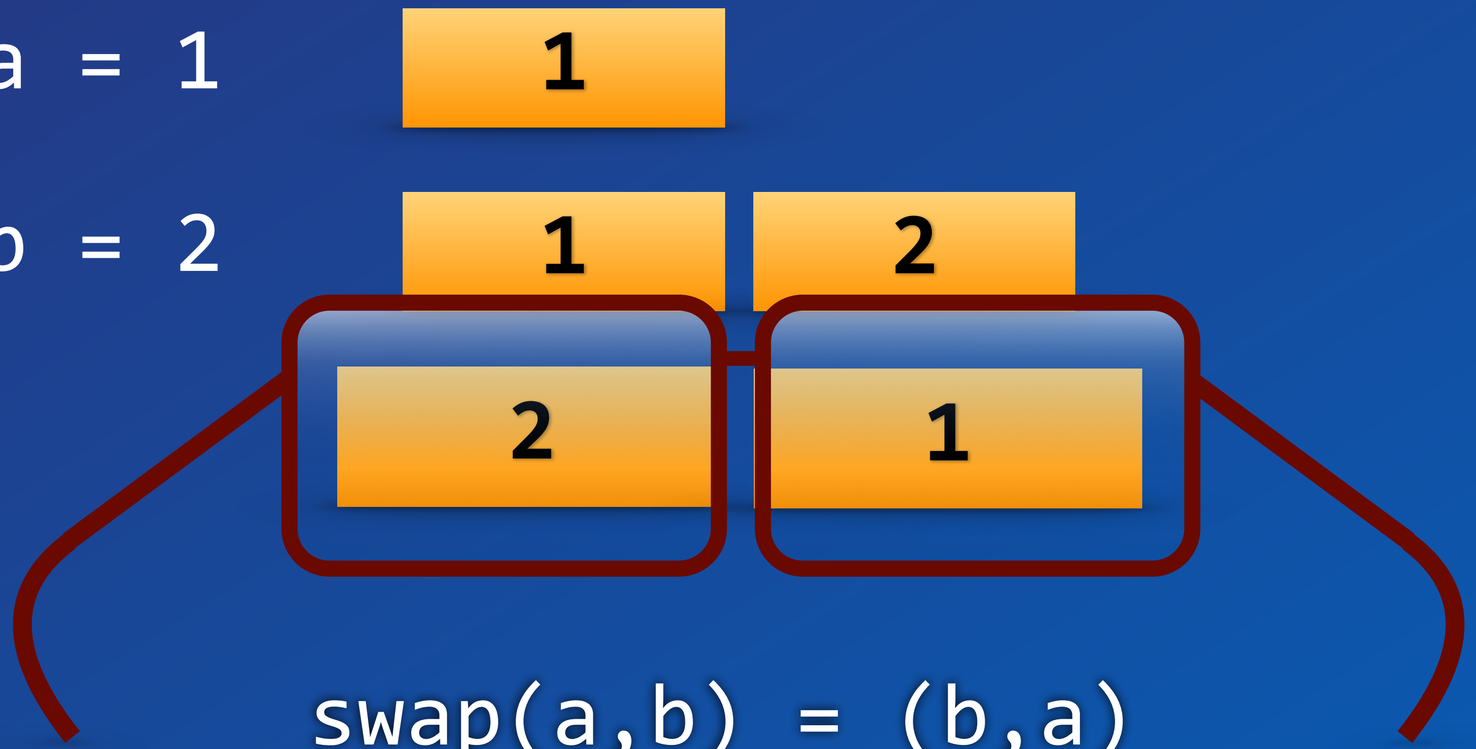
```
a = 1
```


```
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

Go Strong

IDE Support	Safe Refactoring	Design Tool
No silly errors	Less tricky errors	Abstraction
Runtime Efficiency	Communicate	Insight

It’s all based on purity

It’s all based on purity

Pure functions produce the same result given the same arguments.
No observable side effects.

Pure Functions

Runtime Efficiency

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?

Let the type system find out!

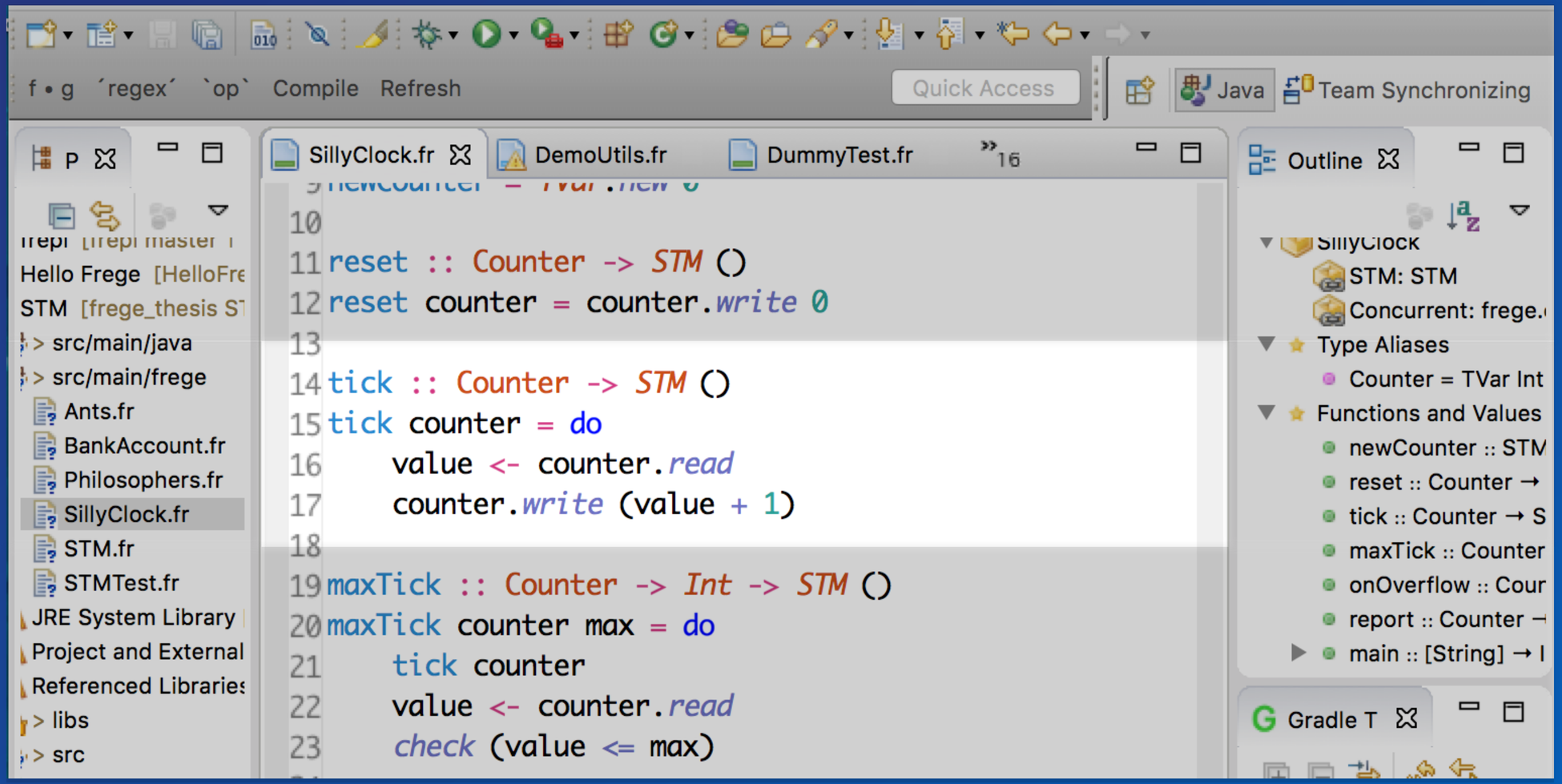
Pure Types

Less tricky errors

make implicit constraints explicit

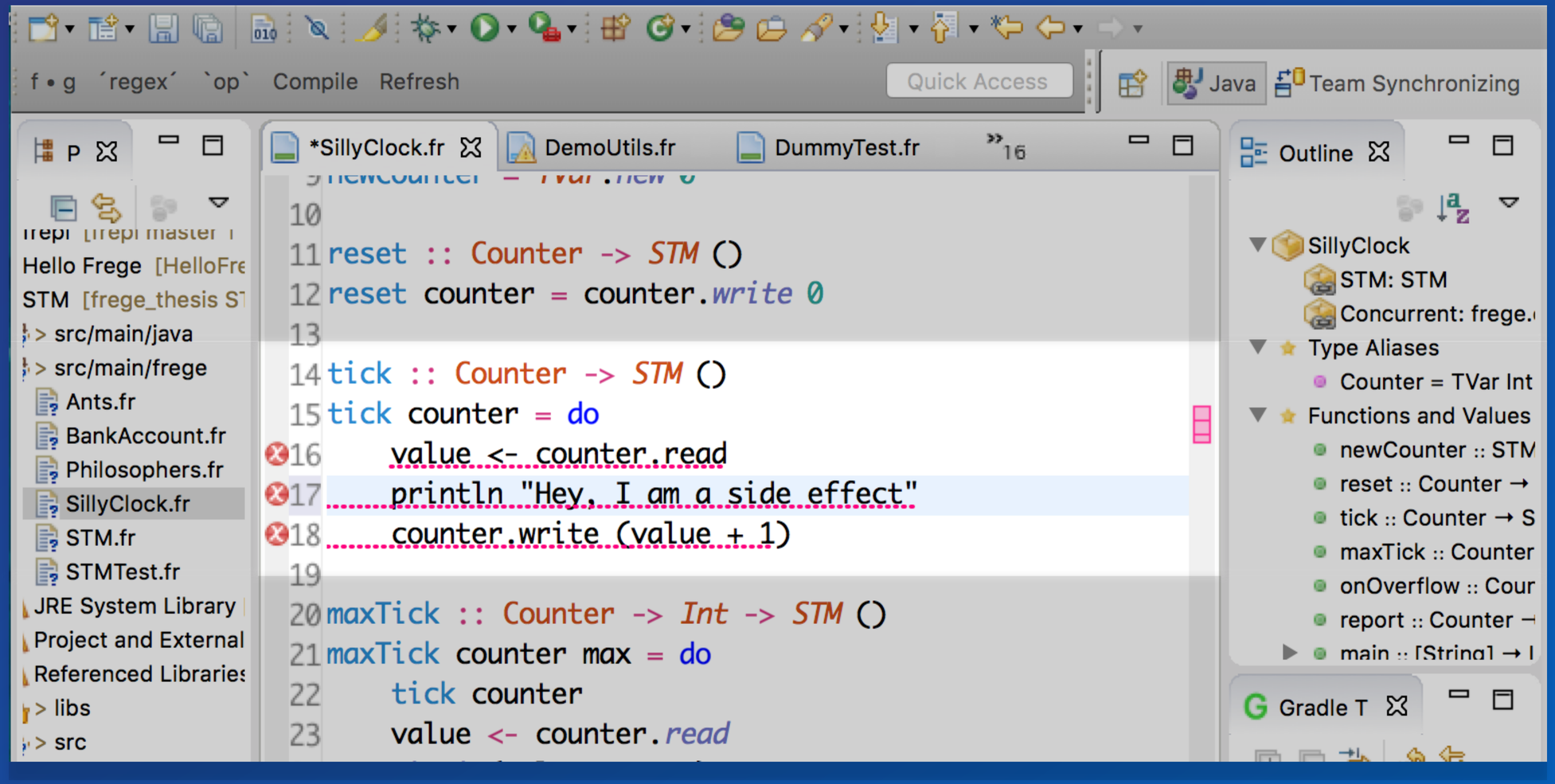
Streams:
    never modify, never do IO
    in a (parallel) map/filter/reduce
JavaFX:
    only touch nodes inside UI thread
    only do IO outside UI thread
Transactions: no IO at all!

No IO in Transactions!



Type inference FTW

Less tricky errors



Random Numbers

RNG.java ParallelMapping.fr

```
1  import java.util.Optional;
2  import java.util.concurrent.atomic.AtomicInteger;
3  import java.util.function.Supplier;
4  import java.util.stream.Stream;
5
6  public class RNG {
7      static Supplier<Integer> countGen(AtomicInteger i) {
8          return (()-> i.getAndIncrement());
9      }
10
11     public static void main(String[] args) {
12         final Supplier<Integer> numbers = countGen(new AtomicInteger(1));
13         final Optional<Integer> sum = Stream
14             .generate(numbers)
15             .limit(10)
16             .parallel()
17             .map(a -> a^2)
18             .reduce((a, b) -> a + b);
19         System.out.println("sum = " + sum);
20     }
21 }
```

Follow along in the
Online REPL
http://86.119.37.112:9999
http://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!

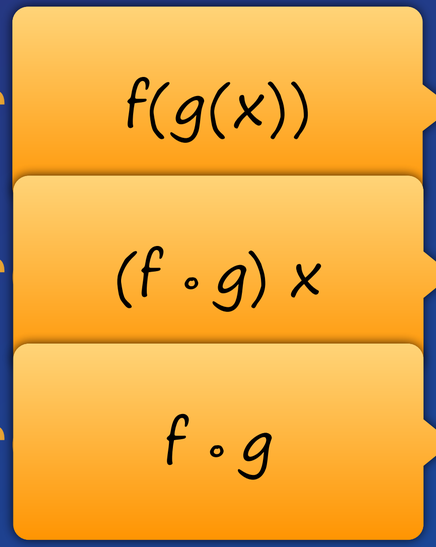
„Currying“, „schönfinkeling“, or „partial function application“. Concept invented by Gottlob Frege.

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




```
fr = twotimes (threetimes x)
fr = (twotimes . threetimes)x
fr = twotimes . threetimes
```

```
frege> six 2

12
```

Pattern Matching

```
frege> times 0 (threetimes 2)

0

frege> times 0 b = 0
```

Pattern Matching

```
frege> times 0 (threetimes 2)
0
```

unnecessarily evaluated

```
frege> times 0 b = 0
```

pattern matching

shortcutting

Lazy Evaluation

```
frege> times 0 (length [1..])
0
```

endless sequence

evaluation would never stop

Pattern matching and
non-strict evaluation
to the rescue!

Reduce to the Max

Communicate

The designer/implementor cares about
parameter constraints

The consumer/user cares about
result constraints

Check out Rùnar Bjarnason
„Liberties constrain, constraints liberate“

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) {…}
```

Frege

```
foo :: (α,β) -> α
```

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

a is returned

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 ()
past = millis () - 1000
```

Does not compile!

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

More Native Declarations

```
native println System.out.println :: String -> IO ()
println “Dierk König“
```

```
native getText :: TextInputControl -> JFX String
text <- inputField.getText
println text          - - does not compile!
inIO text println     - - compiles!
```

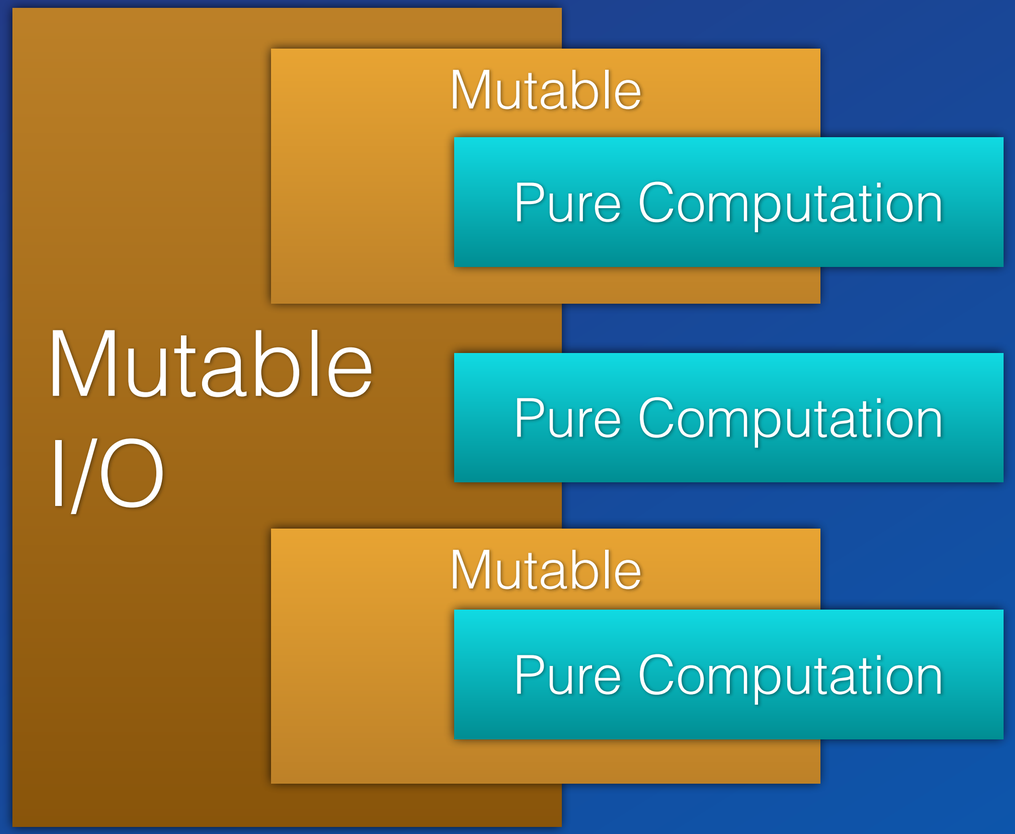
Frege

allows calling Java
but never unprotected!

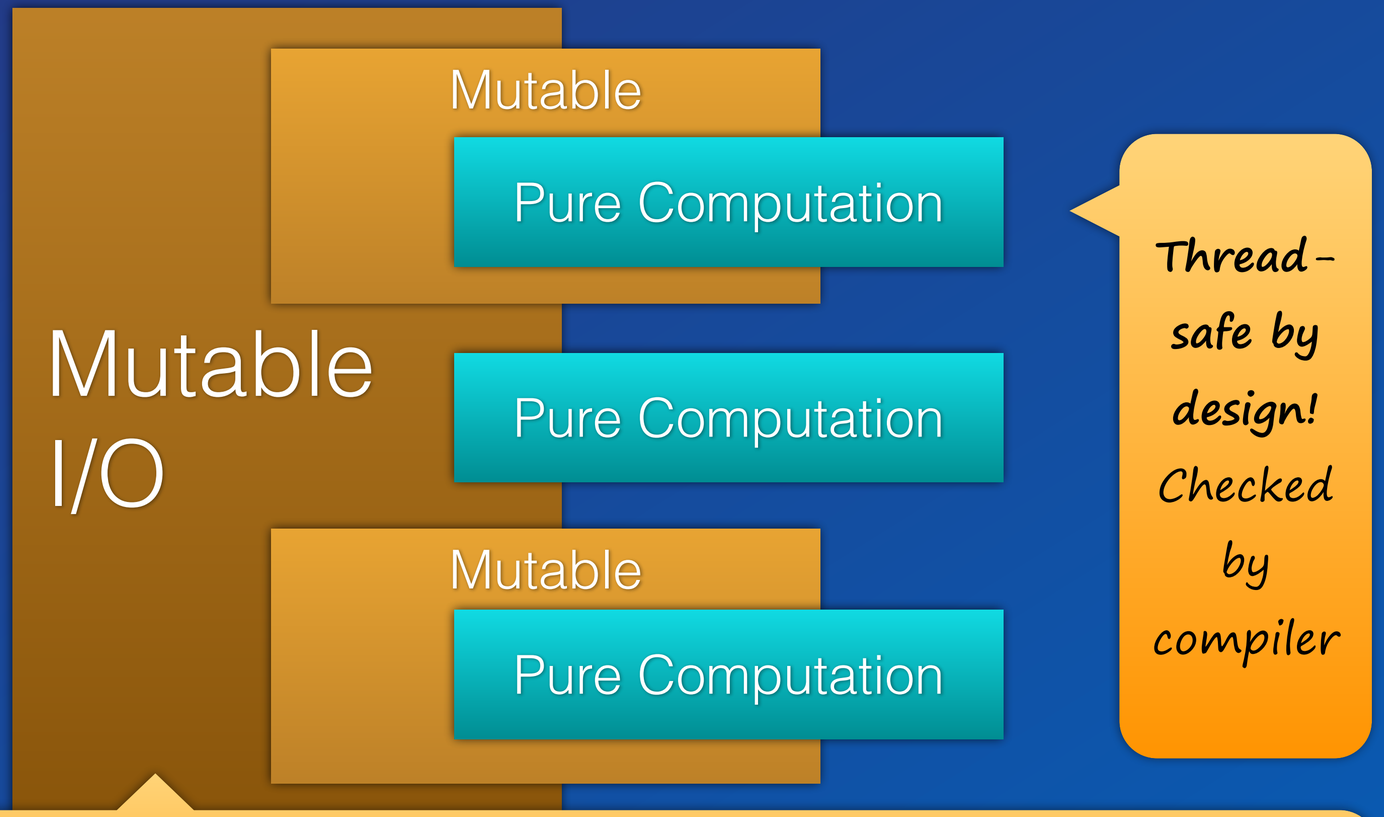
is explicit about effects
just like Haskell

Prerequisite to safe concurrency and deterministic parallelism!

Keep the mess out!



Keep the mess out!



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.

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 bestOf numbers pattern where
                   bestOf n "" = n
                   bestOf n p  = p

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	-	+++

QuickCheck

```
-- An AVL tree is balanced so
that the height of the left and
right subtree differ by at most 1

p_balance = forAll aTree
  (\tree -> abs tree.balance < 2)
```

QuickCheck will create 500 different trees covering all corner cases in creation and validate the invariant. (from Frege source code)

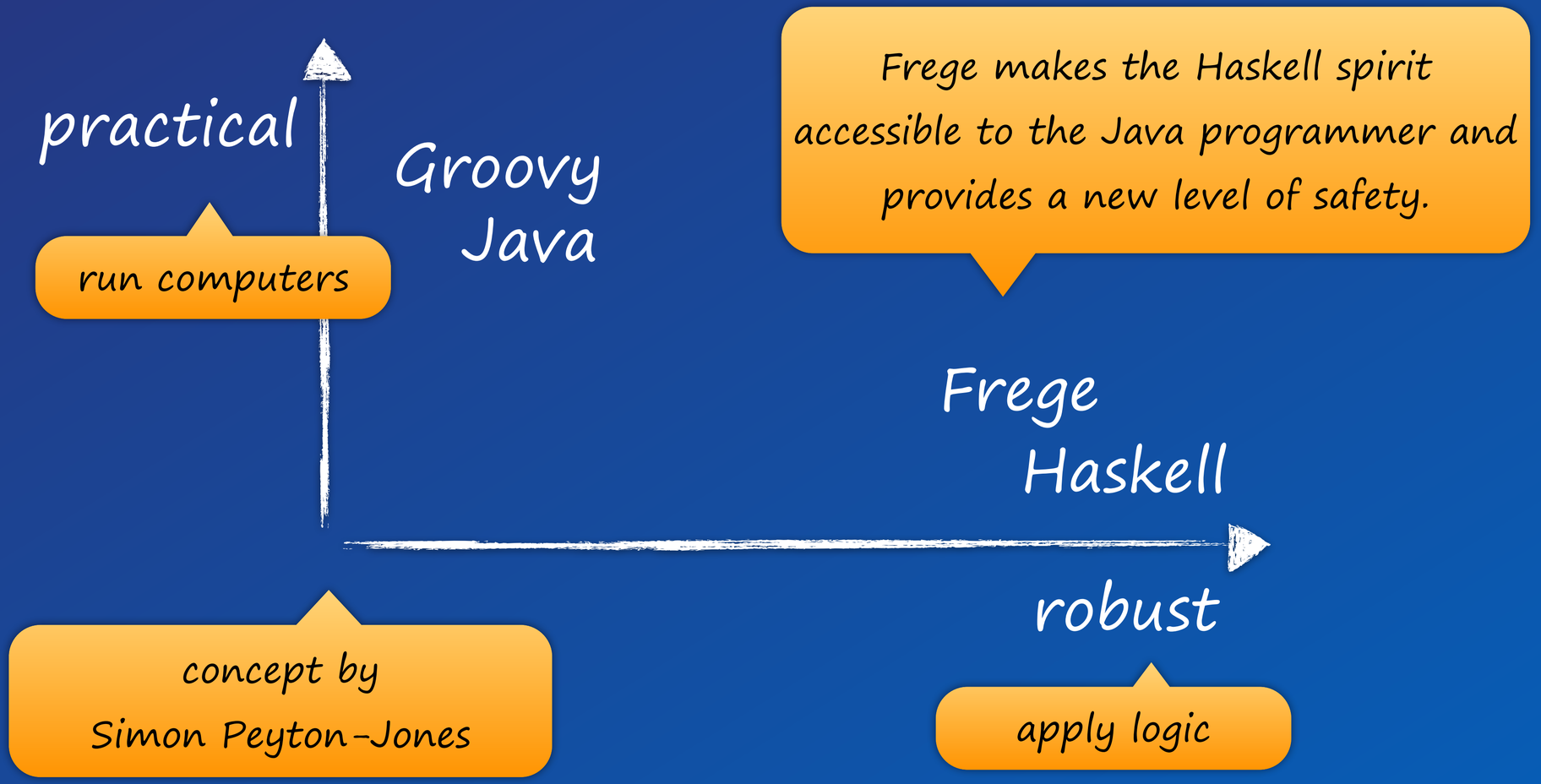
History

Java promise: „No more pointers!“

But Null**Pointer**Exceptions (?)

Frege in comparison

Frege in comparison



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
functional programming

Why FP matters

Enabling incremental development

see FregeGoodness "Incremental Development"

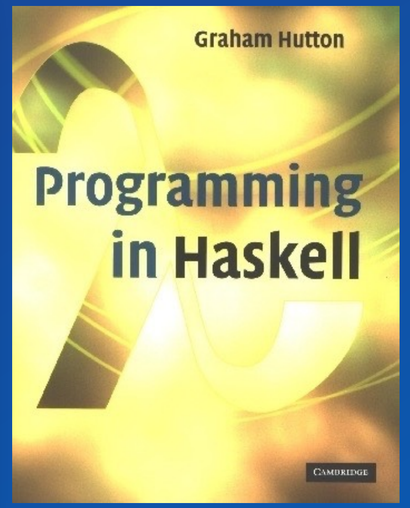
Brush up computational fundamentals

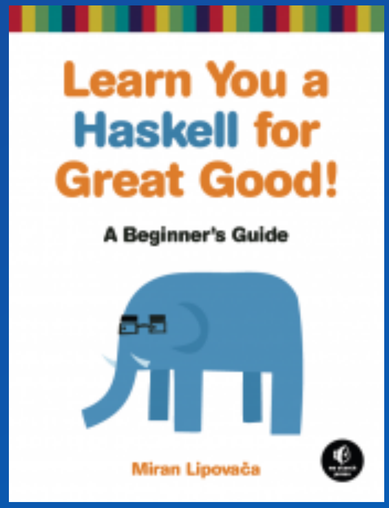
„An investment in knowledge always pays the best interest.“

—Benjamin Franklin

How?

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





Community

Frege compiles Haskell to Java.

It combines both communities.

Popularity: 3500+ github stars

top 10 of 26k Haskell projects

top 0.03% of 1M Java projects

Tool support

All Java tools!

Frege Eclipse, IDEA, VS Code plugin

Haskell mode in editors/IDEs

Maven, Gradle, Leinigen, Bazel, make

Compiler, doc tool, REPLs, quickcheck

Training Material

All Haskell material applies:

- MOOCs, Books, Lectures, Videos
- Scientific Papers

Specialized Frege training
at Karakun

Questions?

Prof. Dierk König

@mittie

FGA

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