PEP Scala (5)

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Office: N7.07 (North Wing, Bush House)

Slides & Code: KEATS

Office Hours: Thursdays 12:00 – 14:00
Additionally: (for Scala) Tuesdays 10:45 – 11:45

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	PDF: A Crash-Course in Scala

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Marks for Preliminary 8

Raw marks (265 submissions):

- 4%: 211
- 3%: 11
- 2%: 14
- 1%: 8
- 0%: 21

(plagiarism/collusion interviews ongoing again!)

Plan for Today

- Being Lazy
- Polymorphic Types
- Immutable OOP
- Making Fun about Scala

How To calcululate 100 Mio Collatz Series?

```
(1L to 100_000_000).map(collatz).max
```

Polyorphic Types

To be avoided:

```
def length_string_list(lst: List[String]): Int =
 lst match {
    case Nil => 0
    case x::xs => 1 + length_string_list(xs)
 }


def length_int_list(lst: List[Int]): Int =
 lst match {
    case Nil => 0
    case x::xs => 1 + length_int_list(xs)
 }
```

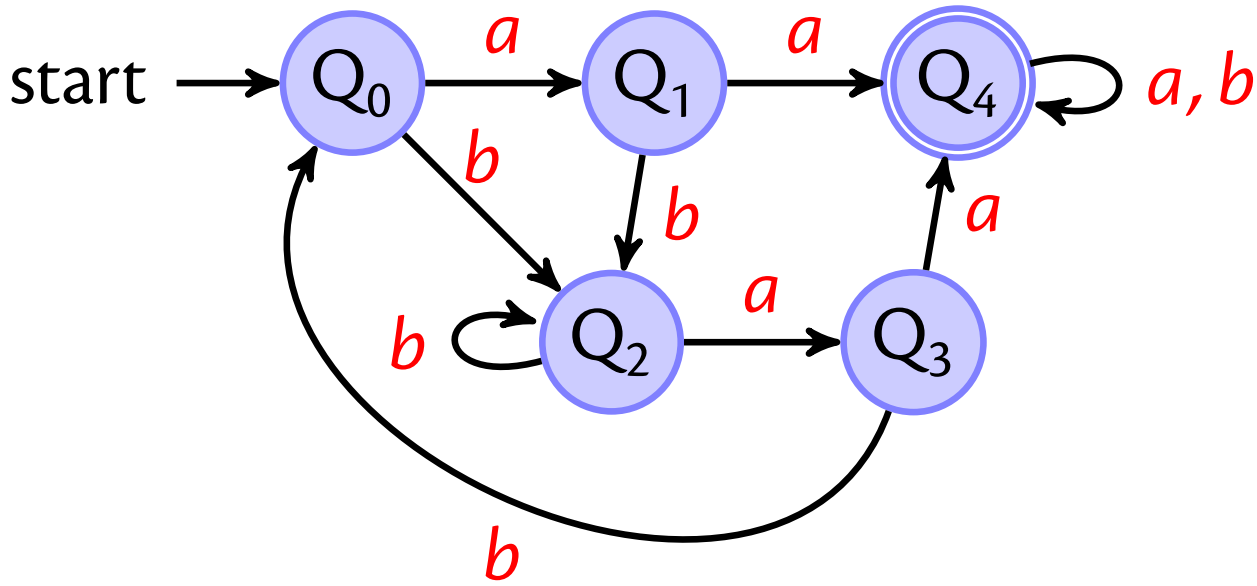
Polyorphic Types

```
def length[A](lst: List[A]): Int = lst match {
  case Nil => 0
  case x::xs => 1 + length(xs)
}

length(List("1", "2", "3", "4"))
length(List(1, 2, 3, 4))


def map[A, B](lst: List[A], f: A => B): List[B] =
 lst match {
   case Nil => Nil
   case x::xs => f(x)::map(xs, f)
 }
```

DFAs



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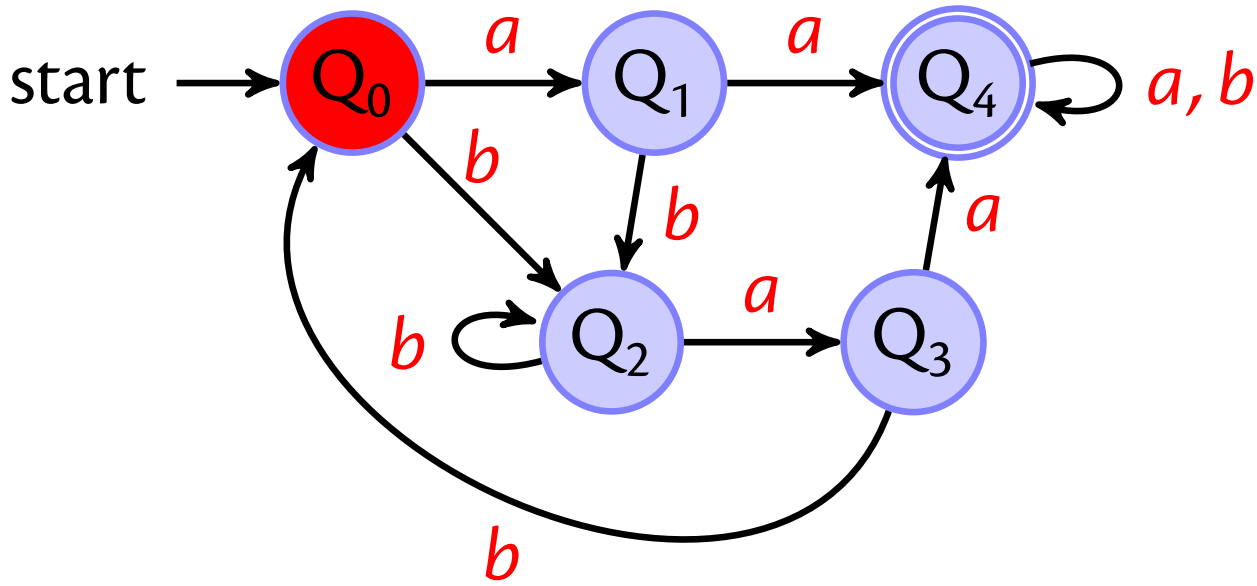

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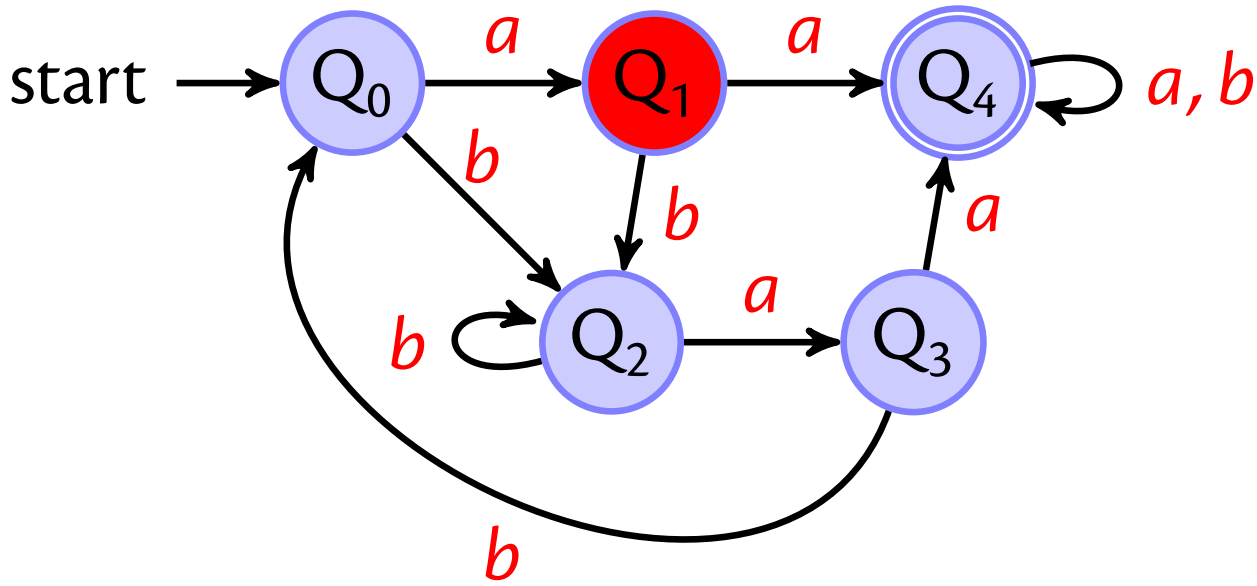

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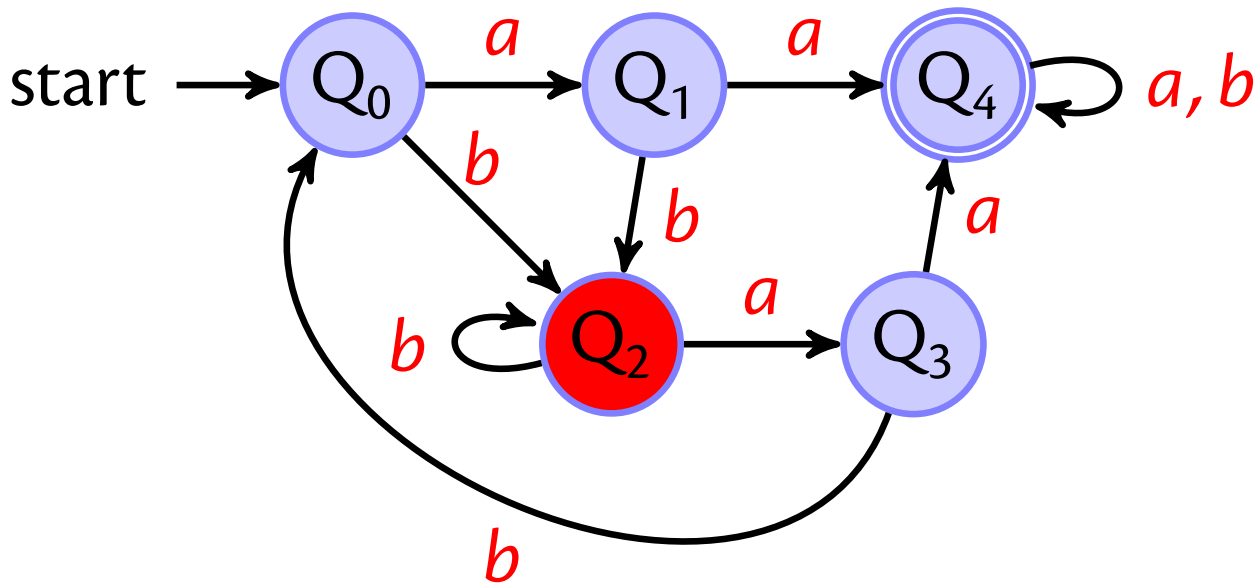

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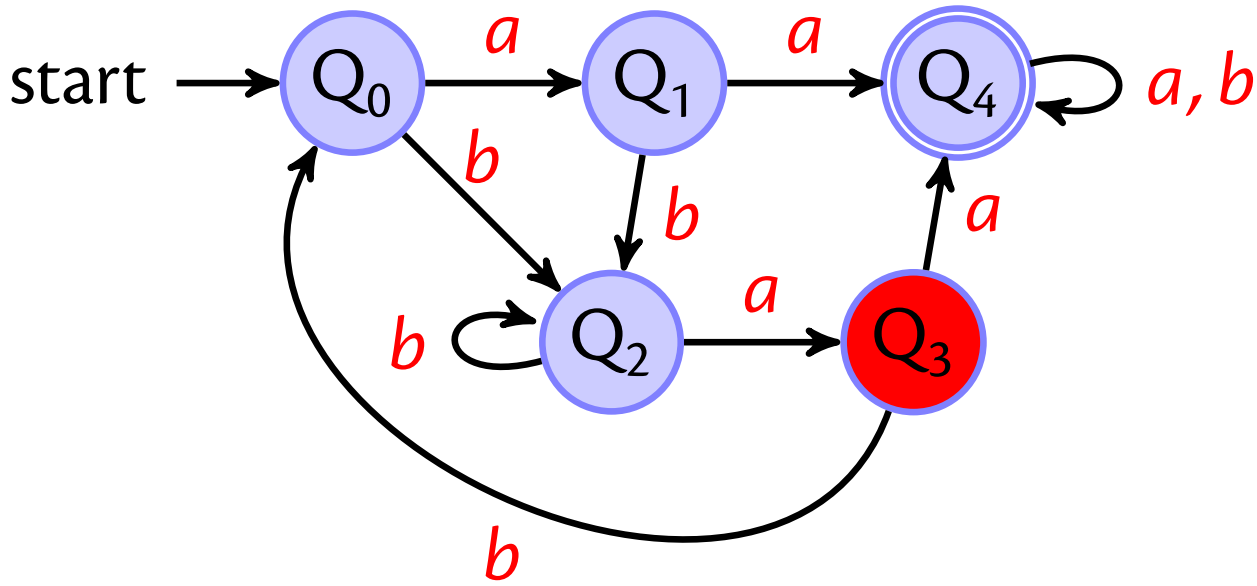

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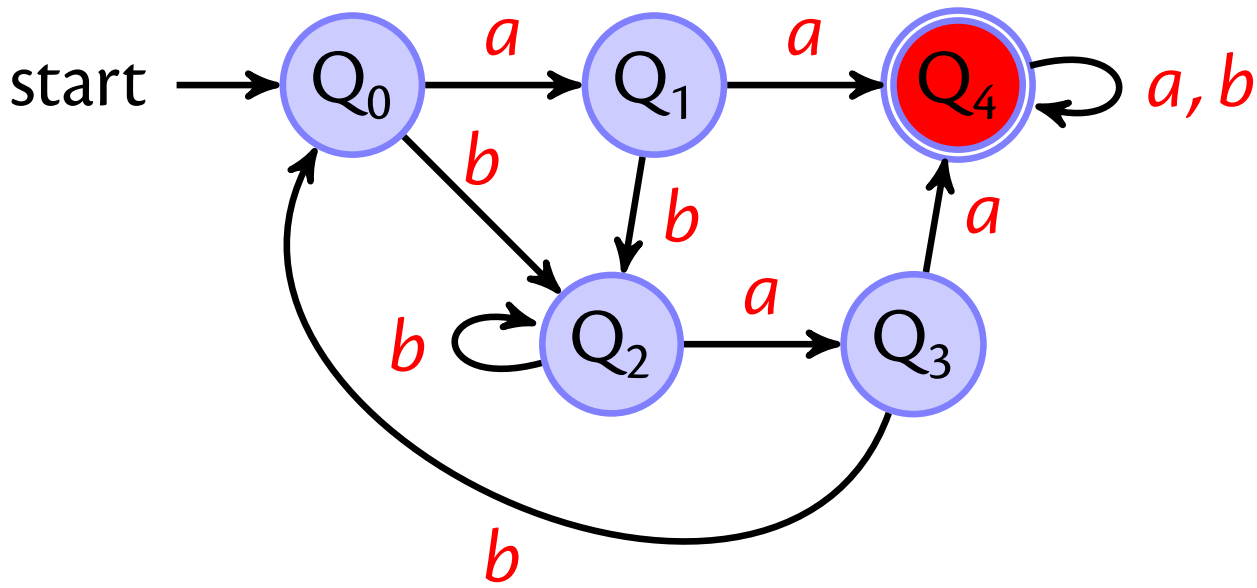

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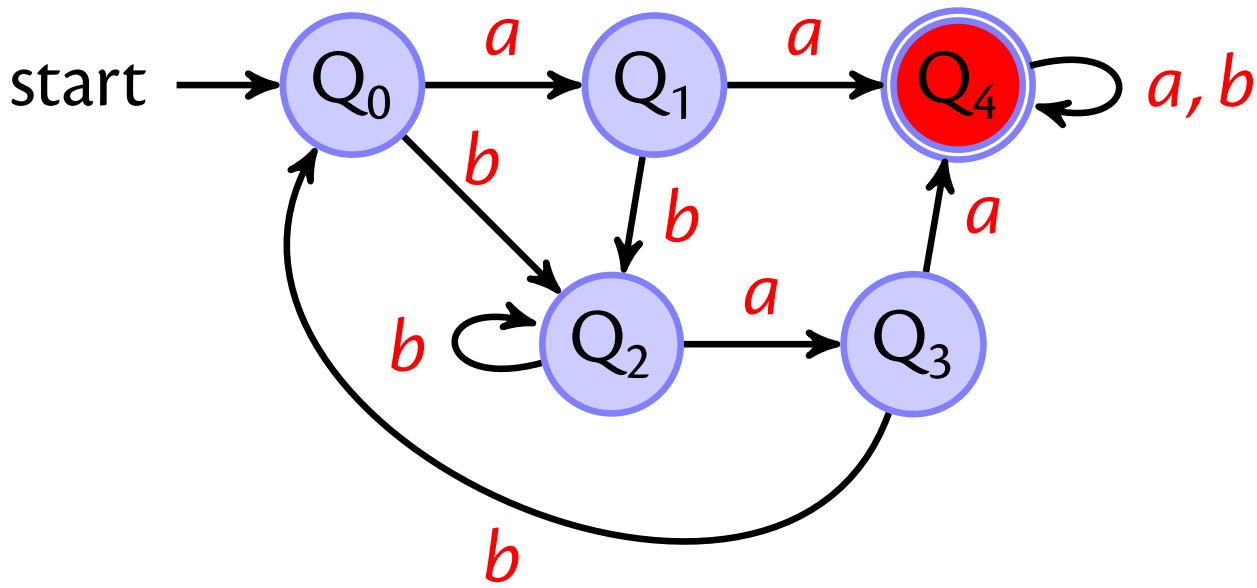


abaaa $\Rightarrow$ **yes**

DFAs

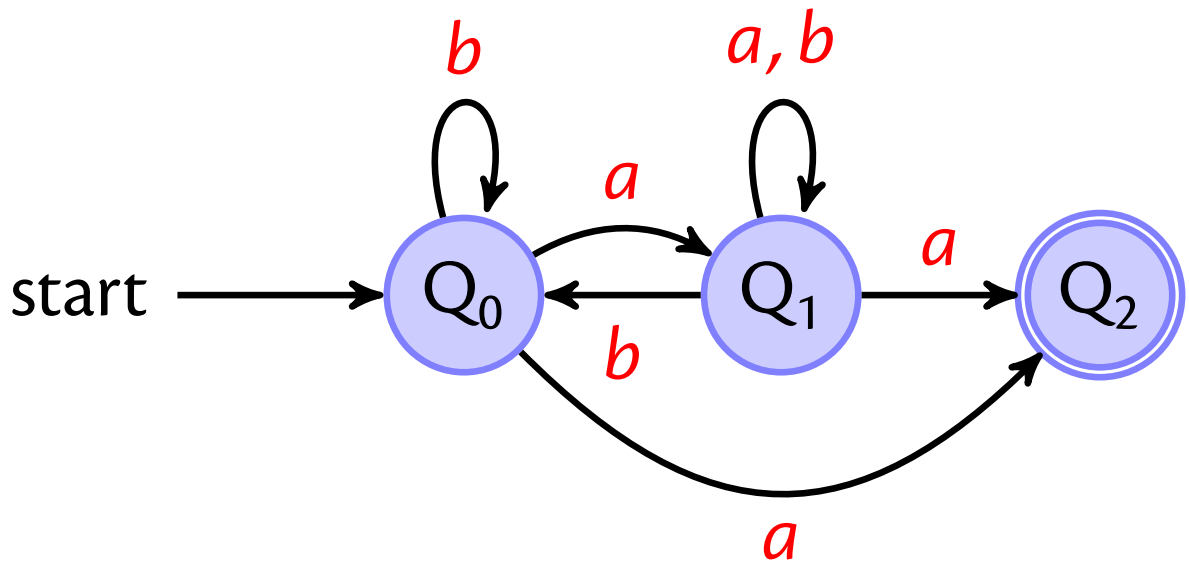
A **deterministic finite automaton** (DFA) consists of 5 things:

- an alphabet Σ
- a set of states Qs
- one of these states is the start state Q_0
- some states are accepting states F, and
- there is transition function δ

which takes a state and a character as arguments and produces a new state; this function might not be everywhere defined

$$A(\Sigma, Qs, Q_0, F, \delta)$$

NFAs



Compilers 6CCS3CFL

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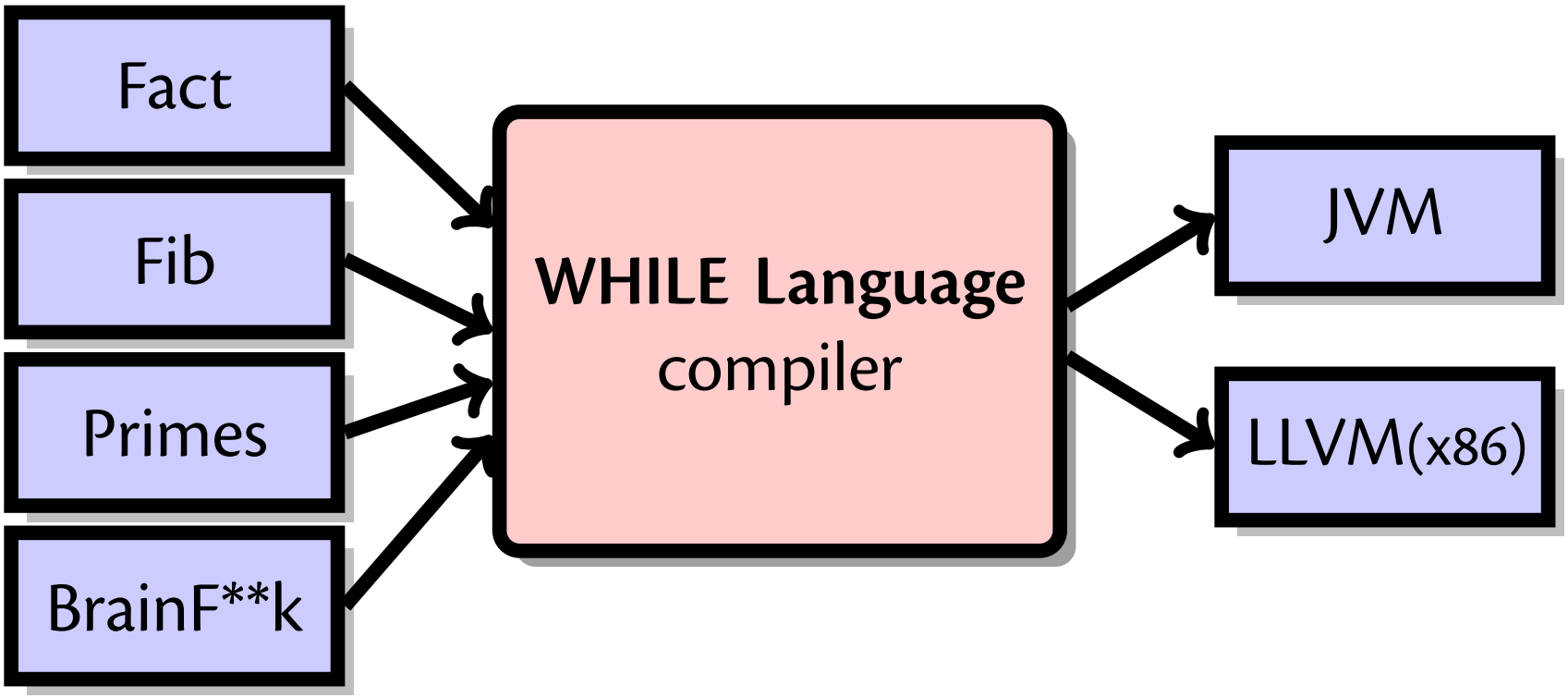


Dijkstra on Testing

"Program testing can be a very effective way to show the presence of bugs, but it is hopelessly inadequate for showing their absence."

Proving Programs to be Correct

Theorem: There are infinitely many prime numbers.

Proof ...

similarly

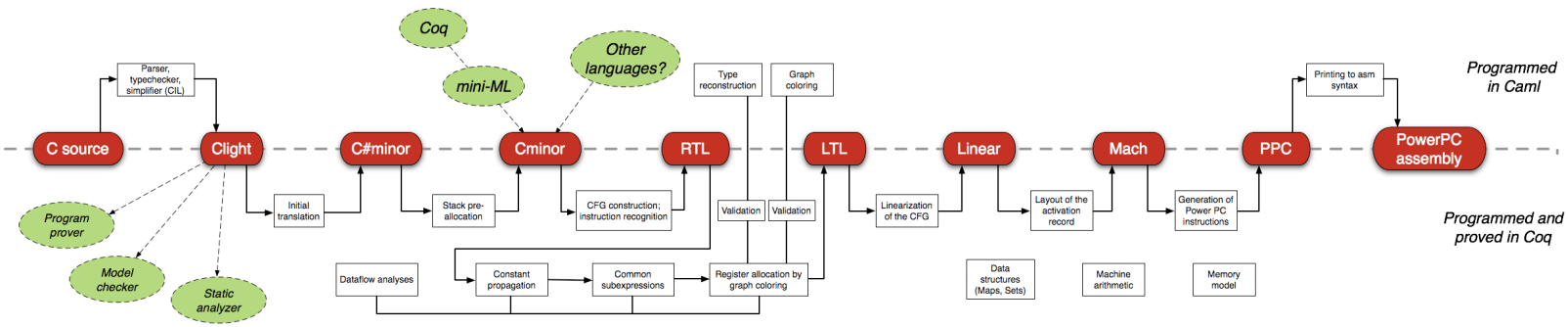
Theorem: The program is doing what it is supposed to be doing.

Long, long proof ...

This can be a gigantic proof. The only hope is to have help from the computer. 'Program' is here to be understood to be quite general (compiler, OS, ...).

Can This Be Done?

- in 2011, verification of a small C-compiler (CompCert)
  - "if my input program has a certain behaviour, then the compiled machine code has the same behaviour"
  - is as good as `gcc -O1`, but much, much less buggy



Fuzzy Testing C-Compilers

- tested GCC, LLVM and others by randomly generating C-programs
- found more than 300 bugs in GCC and also many in LLVM (some of them highest-level critical)

- about CompCert:

> "The striking thing about our CompCert results is that the middle-end bugs we found in all other compilers are absent. As of early 2011, the under-development version of CompCert is the only compiler we have tested for which Csmith cannot find wrong-code errors. This is not for lack of trying: we have devoted about six CPU-years to the task."

seL4 / Isabelle

- verified a microkernel operating system (≈8000 lines of C code)
- US DoD has competitions to hack into drones; they found that the isolation guarantees of seL4 hold up
- CompCert and seL4 sell their code

seL4 / Isabelle

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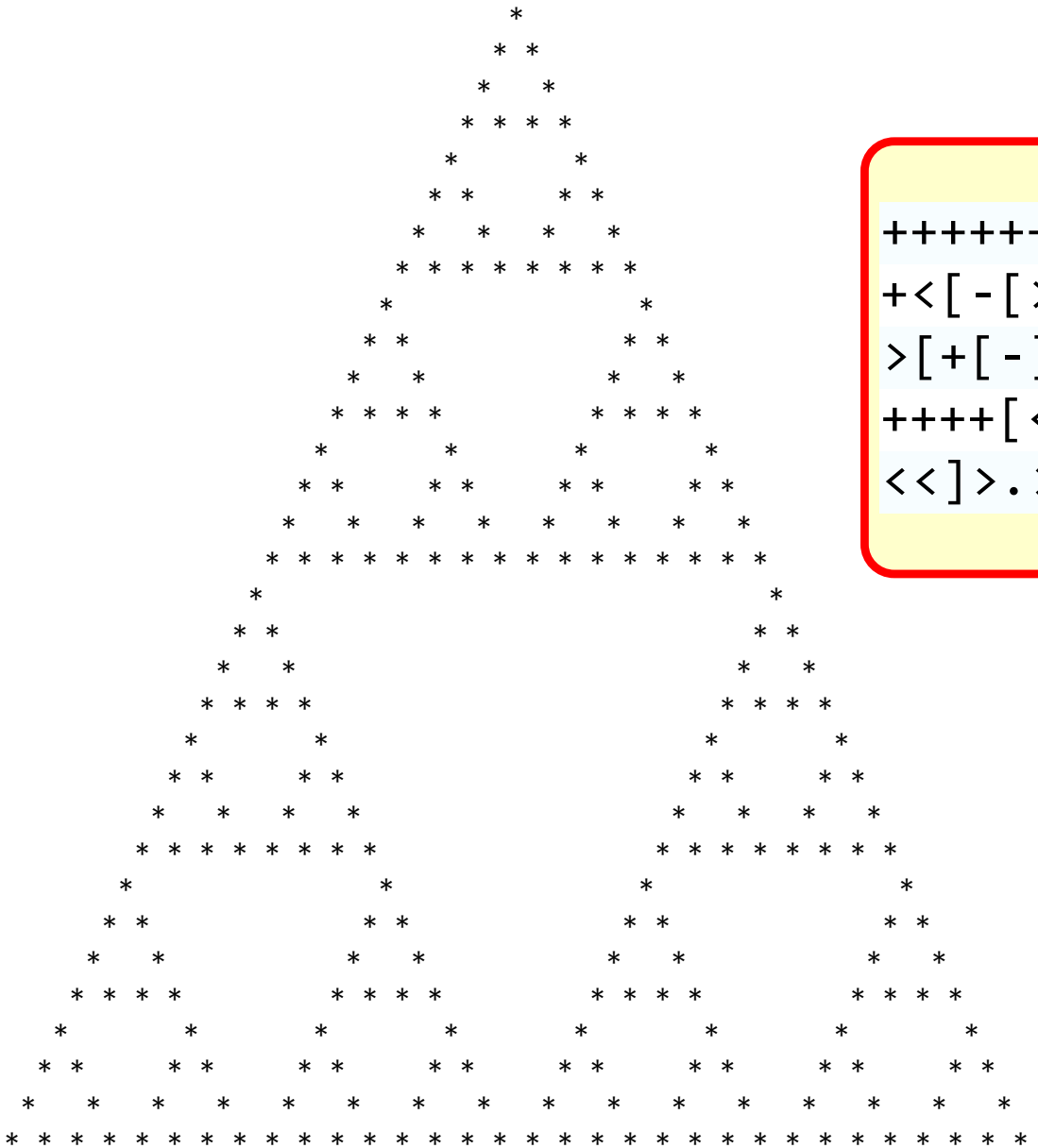
Where to go on from here?

- Martin Odersky (EPFL)…he is currently throwing out everything and starts again with the dotty compiler for Scala 3.0
- Elm (`http://elm-lang.org`)…web applications with style
- Haskell, Ocaml, Standard ML, Scheme, …

Questions?



```
++++++++[>+>++++<<-]>++>>
+<[-[>>+<<-]+>>]>+[-<<<[-
>[+[-]+>++>>>-<<]<[<]>>++
++++[<<+++++>>-]+<<++.[-]
<<]>.>+[>>]>+]
```