Programming Languages and Environments (Lecture 1)

LEI - Licenciatura em Engenharia Informática

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SCIENCE & TECHNOLOGY

Programming Languages

Alonzo Church (1903 - 1995)

- Foundational work on Programming Languages.
- Devised the formal system of Lambda Calculus:

$$E ::= \; x \mid \; \lambda x.E \; \mid \; E \; E$$

$$(\lambda x.E) \; E' \longrightarrow E\{E'/x\} \qquad \frac{E \longrightarrow E''}{E \; E' \longrightarrow E'' \; E'}$$

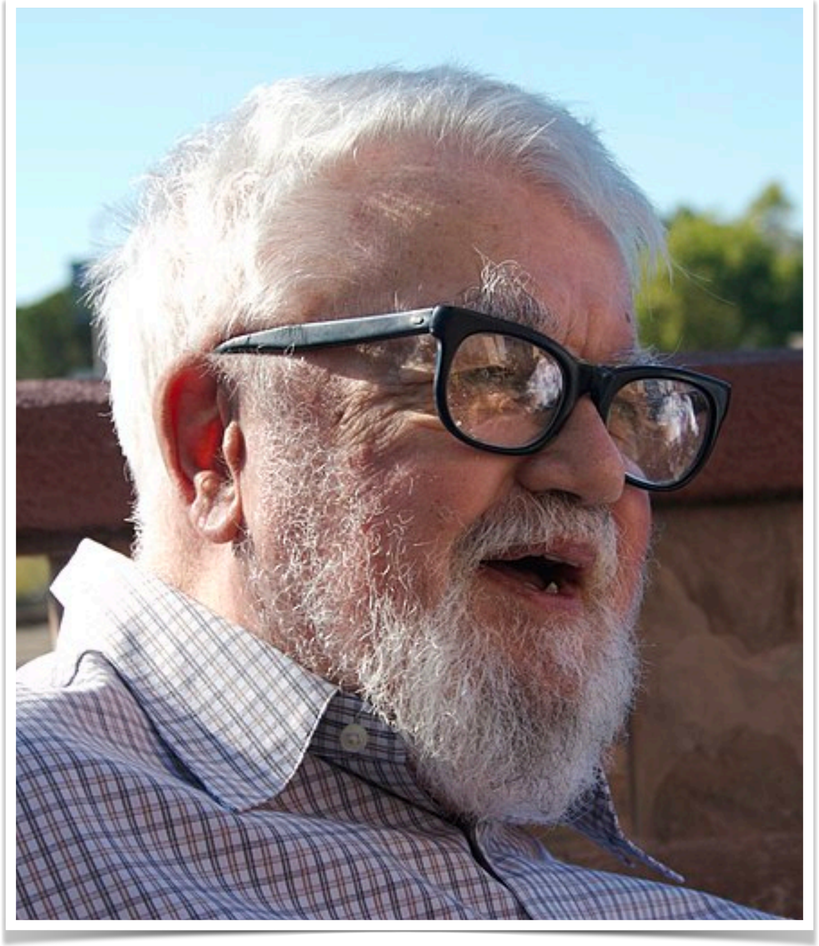
- Proved that Hilbert's *Entscheidungsproblem* (decision problem) is undecidable.

Alan Turing (1912 - 1954)

- Turing Machine
- Father of the First Computer (WWII)
- Undecidability of the *halting problem*.
- Proved that Lambda Calculus is Turing Complete.

John McCarthy (1927 - 2011)

- LISP (1960) and *garbage collection.*
- LISP = LISt Processor.
- Recipient of the Turing Award in 1971.
- Native features of LISP:
  - Tree data structures
  - Garbage collection
  - Dynamic typing
  - Higher-order functions
  - Recursion
  - REPL execution

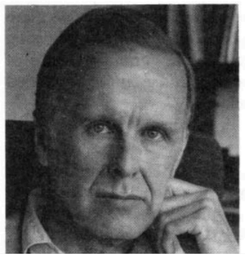


John Backus (1924 - 2007)

- Fortran (1966), BNF e FP.
- Member of the committee that developed ALGOL 58, e ALGOL 60.
- Recipient of the Turing Award in 1977.
- FP (Point Free Style) - 1977.

Can Programming Be Liberated from the von Neumann Style? A Functional Style and Its Algebra of Programs

John Backus
IBM Research Laboratory, San Jose



Conventional programming languages are growing ever more enormous, but not stronger. Inherent defects at the most basic level cause them to be both fat and weak: their primitive word-at-a-time style of programming inherited from their common ancestor—the von Neumann computer, their close coupling of semantics to state transitions, their division of programming into a world of expressions and a world of statements, their inability to effectively use powerful combining forms for building new programs from existing ones, and their lack of useful mathematical properties for reasoning about programs.

Point Free Style does not use parameter names and defines functions only by composition.

```
f = (+ 1)
```

```
f x = x + 1
```

```
sum = foldr (+) 0
```

```
sum' xs = foldr (+) 0 xs
```


https://wiki.haskell.org/Pointfree

Peter Landin (1930 - 2009)

- Abstract Machine SECD for Functional Languages
  - Stack, Environment, Control, Dump
  - Stack Registers and an Associative List (Environment)
  - Instructions: nil, ldc, ld, sel, join, ldf, ap, ret, dum, rap

The Next 700 Programming Languages

P. J. Landin

Univac Division of Sperry Rand Corp., New York, New York

"... today ... 1,700 special programming languages used to 'communicate' in over 700 application areas."—*Computer Software* Issues, an American Mathematical Association Prospectus, July 1965.

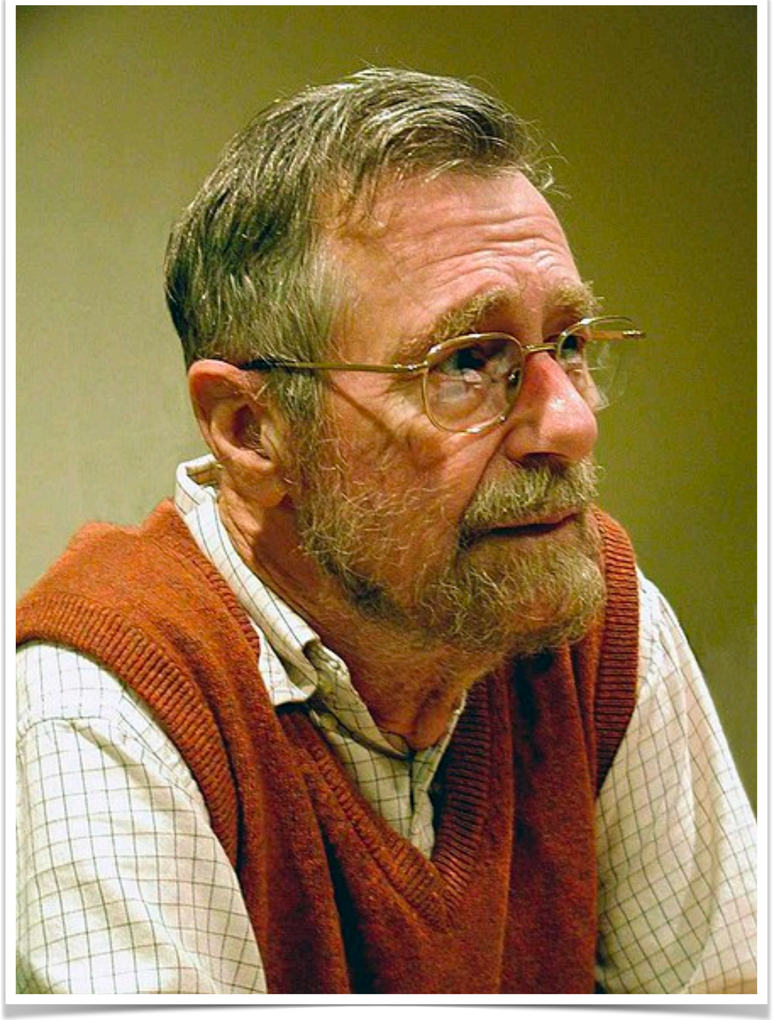
A family of unimplemented computing languages is described that is intended to span differences of application area by a unified framework. This framework dictates the rules about the uses of user-coined names, and the conventions about characterizing functional relationships. Within this frame-

differences in the set of things provided by the library or operating system. Perhaps had ALGOL 60 been launched as a family instead of proclaimed as a language, it would have fielded some of the less relevant criticisms of its deficiencies.

https://en.wikipedia.org/wiki/Peter_Landin

Edsger W. Dijkstra (1930 - 2002)

- Recipient of the Turing Award in 1972.
- Defined the notion of *structured programming*
  - Nested program blocks
  - Absence of Jumps
- Implemented ALGOL's first compiler.



Edgar Dijkstra: Go To Statement Considered Harmful

Go To Statement Considered Harmful

Key Words and Phrases: go to statement, jump instruction, branch instruction, conditional clause, alternative clause, repetitive clause, program intelligibility, program sequencing
CR Categories: 4.22, 5.23, 5.24

EDITOR:

For a number of years I have been familiar with the observation that the quality of programmers is a decreasing function of the density of **go to** statements in the programs they produce. More recently I discovered why the use of the **go to** statement has such

dynamic progress is only characterized when we also give to which call of the procedure we refer. With the inclusion of procedures we can characterize the progress of the process via a sequence of textual indices, the length of this sequence being equal to the dynamic depth of procedure calling.

Let us now consider repetition clauses (like, **while** *B* **repeat** *A* or **repeat** *A* **until** *B*). Logically speaking, such clauses are now superfluous, because we can express repetition with the aid of recursive procedures. For reasons of realism I don't wish to exclude them: on the one hand, repetition clauses can be implemented quite comfortably with present day finite equipment; on

Tony Hoare (1934)

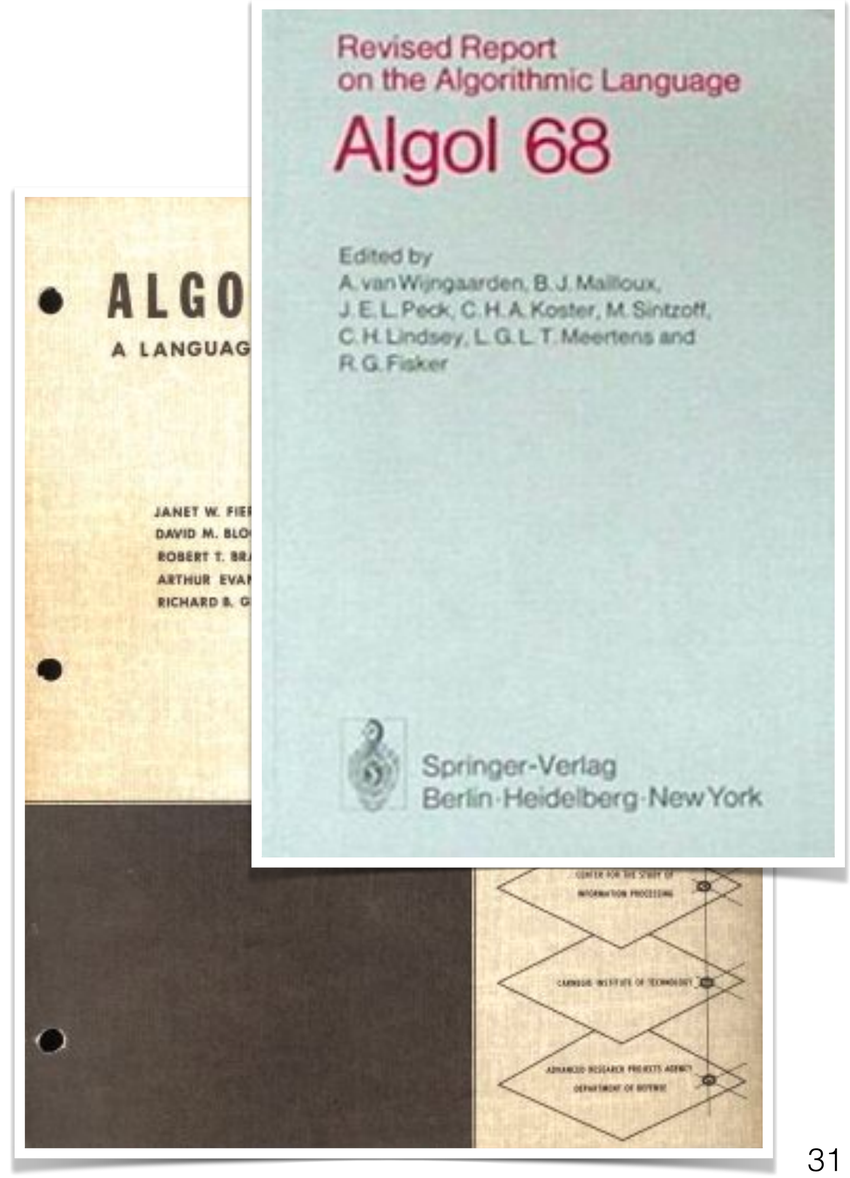
- Recipient of the Turing Award in 1980.
- Noteworthy contributions:
  - Programming Languages (ALGOL)
  - Algorithms (Quick Sort)
  - Operating Systems (Monitors)
  - Software Verification (Hoare Logic)
  - Concurrent Programming (CSP)
- "Null References: The Billion Dollar Mistake"

https://en.wikipedia.org/wiki/Tony_Hoare

The ALGOL Family

- Concurrent Imperative Language with multiple Paradigms.
- Strongly typed
- Object-oriented
- Null references

Top: John McCarthy, Fritz Bauer, Joe Wegstein. Bottom: John Backus, Peter Naur, Alan Perlis

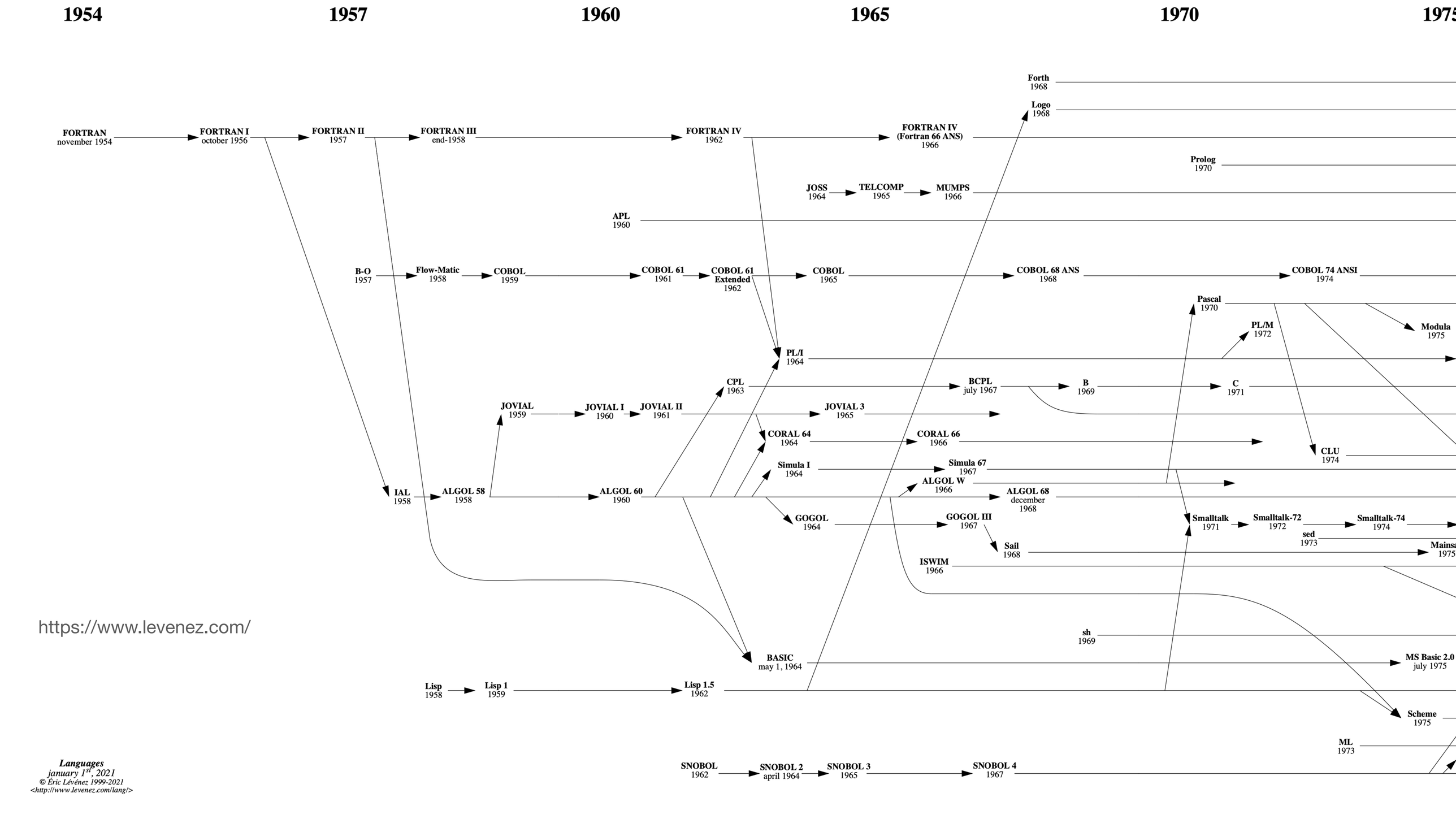


https://www-formal.stanford.edu/jmc/pictures.html

Robin Milner (1934-2010)

- Turing award 1991
- Contributions:
  - LCF (Theorem Prover)
  - ML (Meta Language), a general-purpose FPL,
  - Polymorphic Hindley–Milner type system (type inference)
  - CCS & Pi-Calculus

https://en.wikipedia.org/wiki/Robin_Milner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(Fortran 66 ANS)
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Logo
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Prolog
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GOGOL
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GOGOL III
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Smalltalk
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1965
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https://www.levenez.com/
Languages
january 1st, 2021
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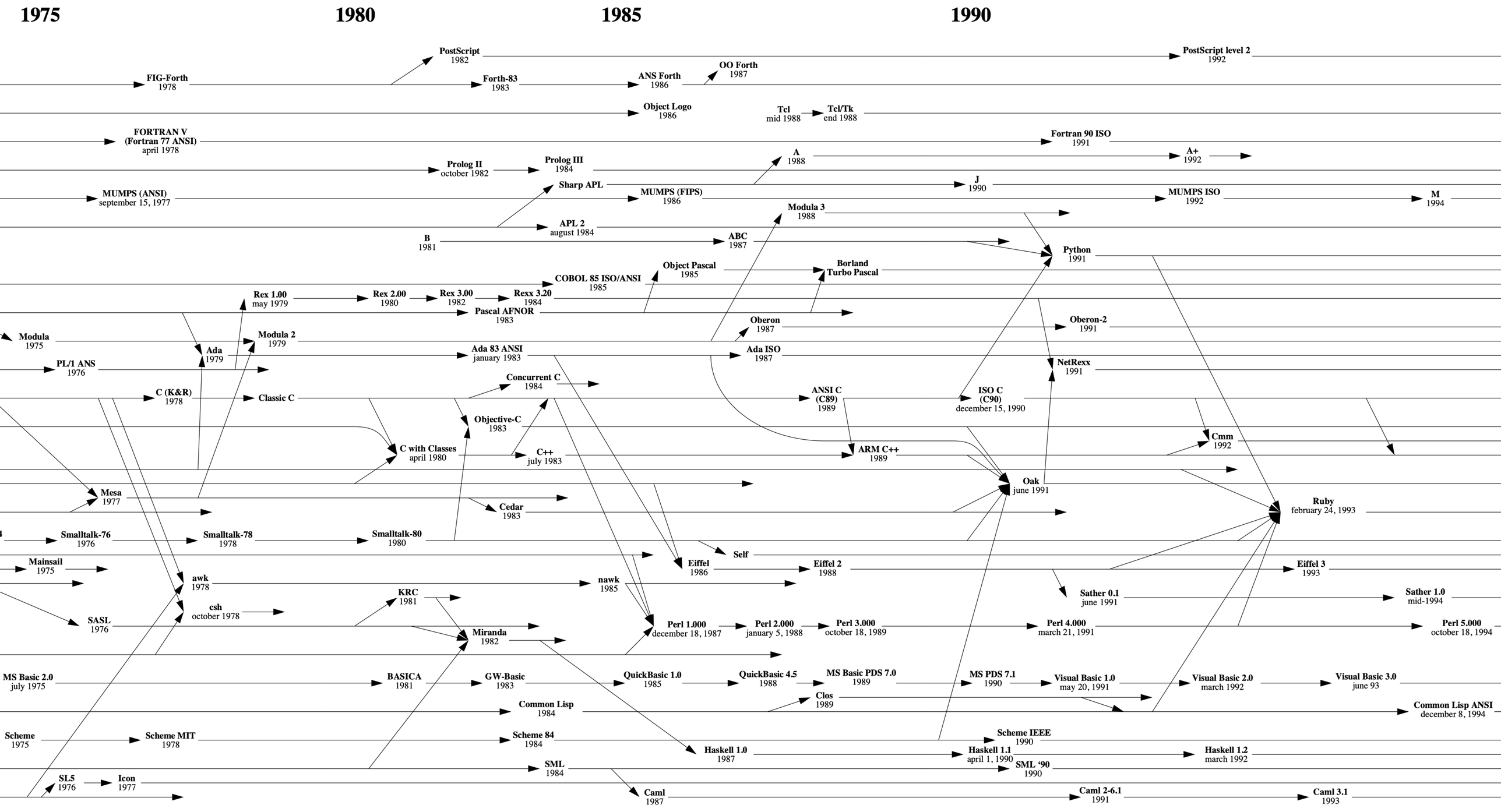
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Object Logo
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Tcl
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Tcl/Tk
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Fortran 90 ISO
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Prolog II
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Prolog III
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Sharp APL
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Pascal AFNOR
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Modula
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Ada ISO
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NetRexx
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PL/1 ANS
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C (K&R)
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Classic C
ANSI C
(C89)
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ISO C
(C90)
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Objective-C
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Cmm
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C with Classes
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C++
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Ruby
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Smalltalk-76
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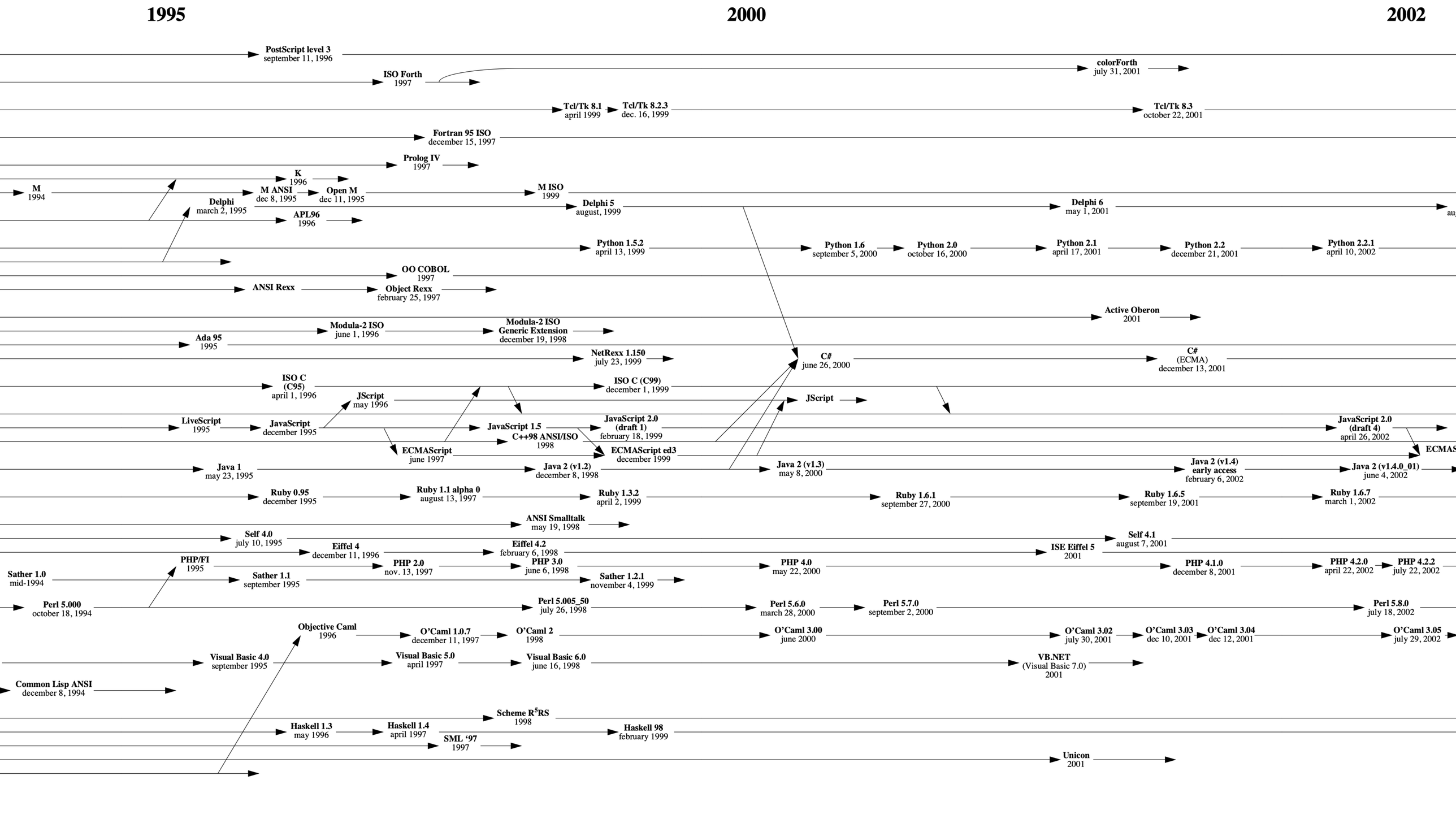
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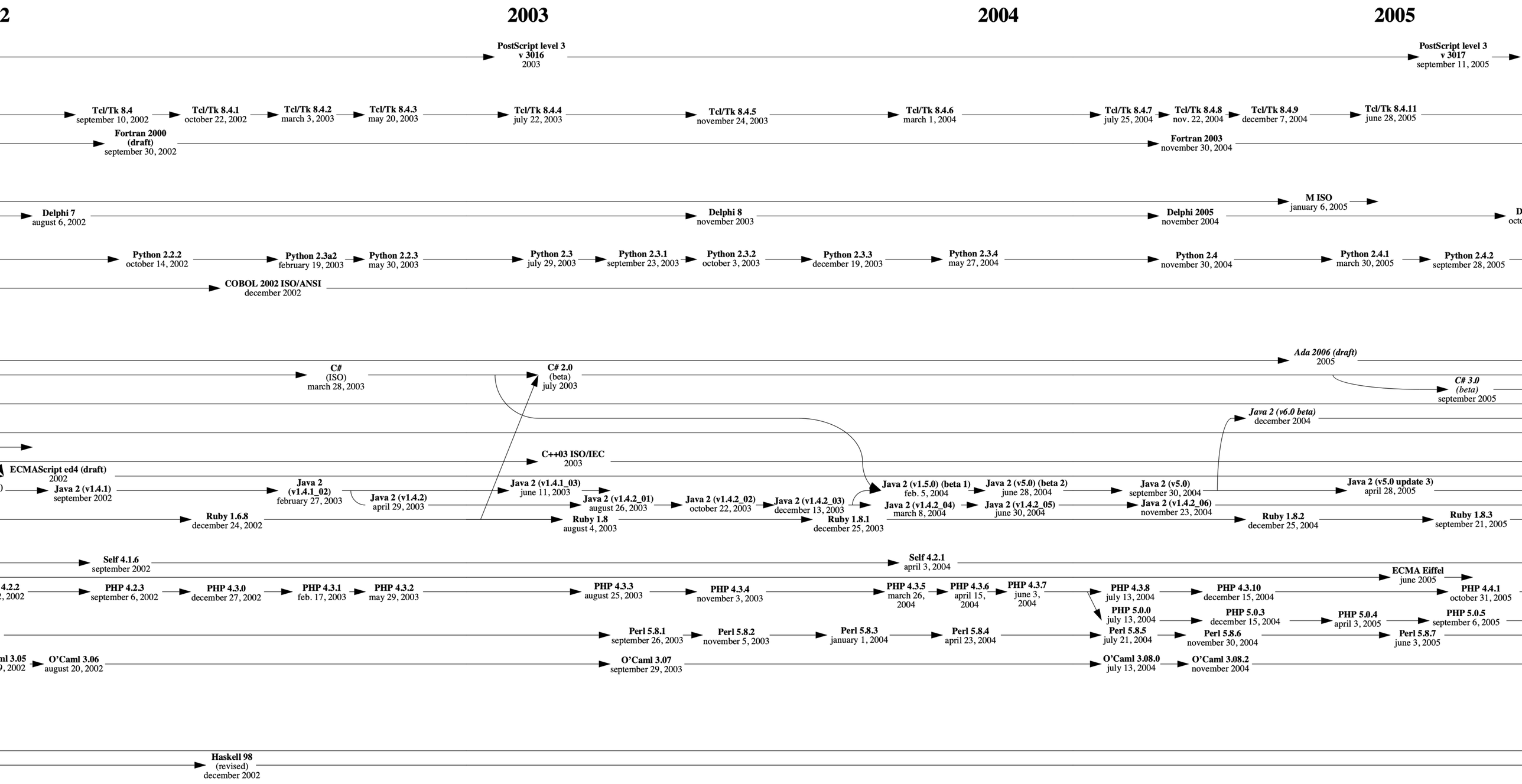
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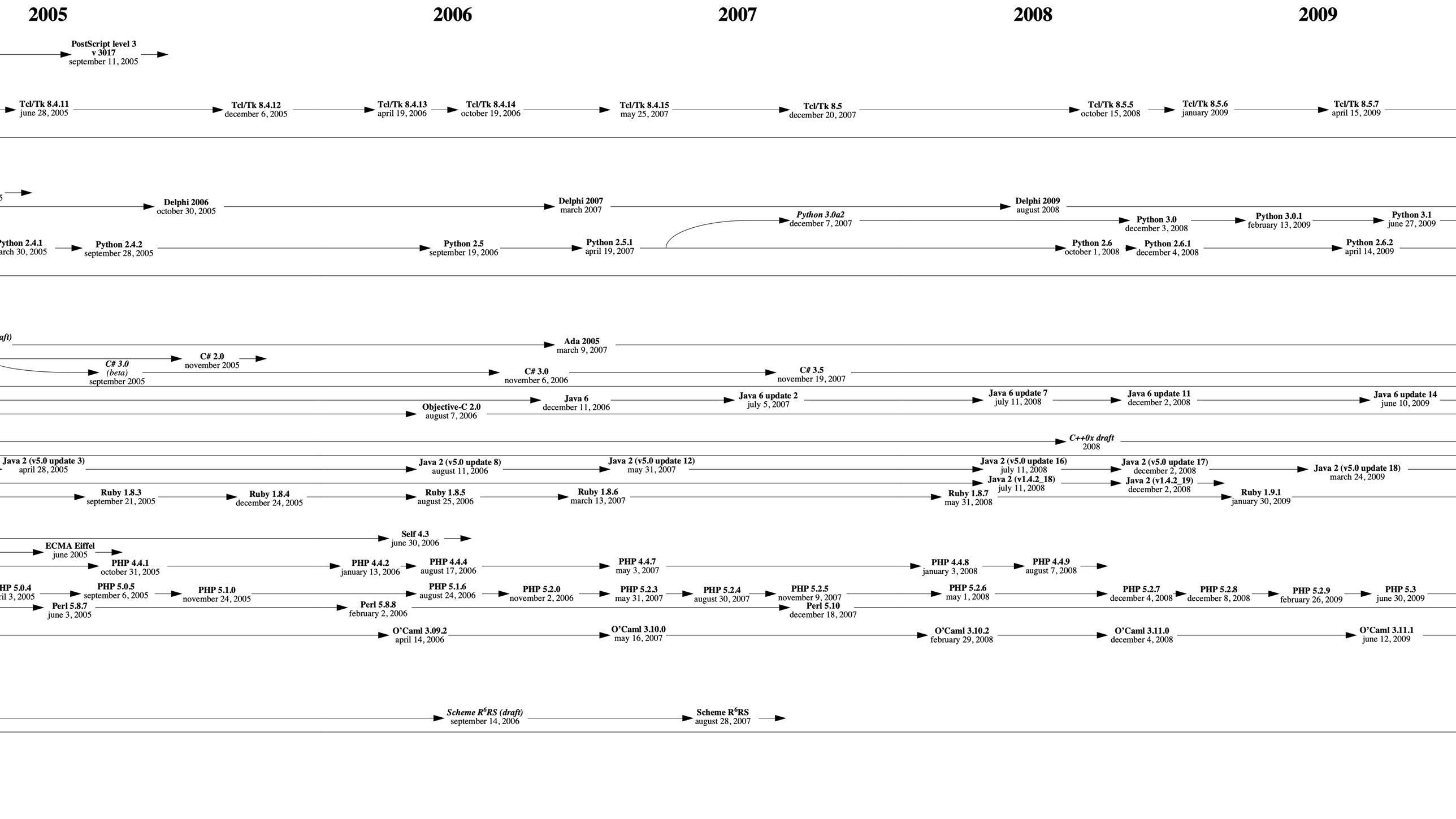
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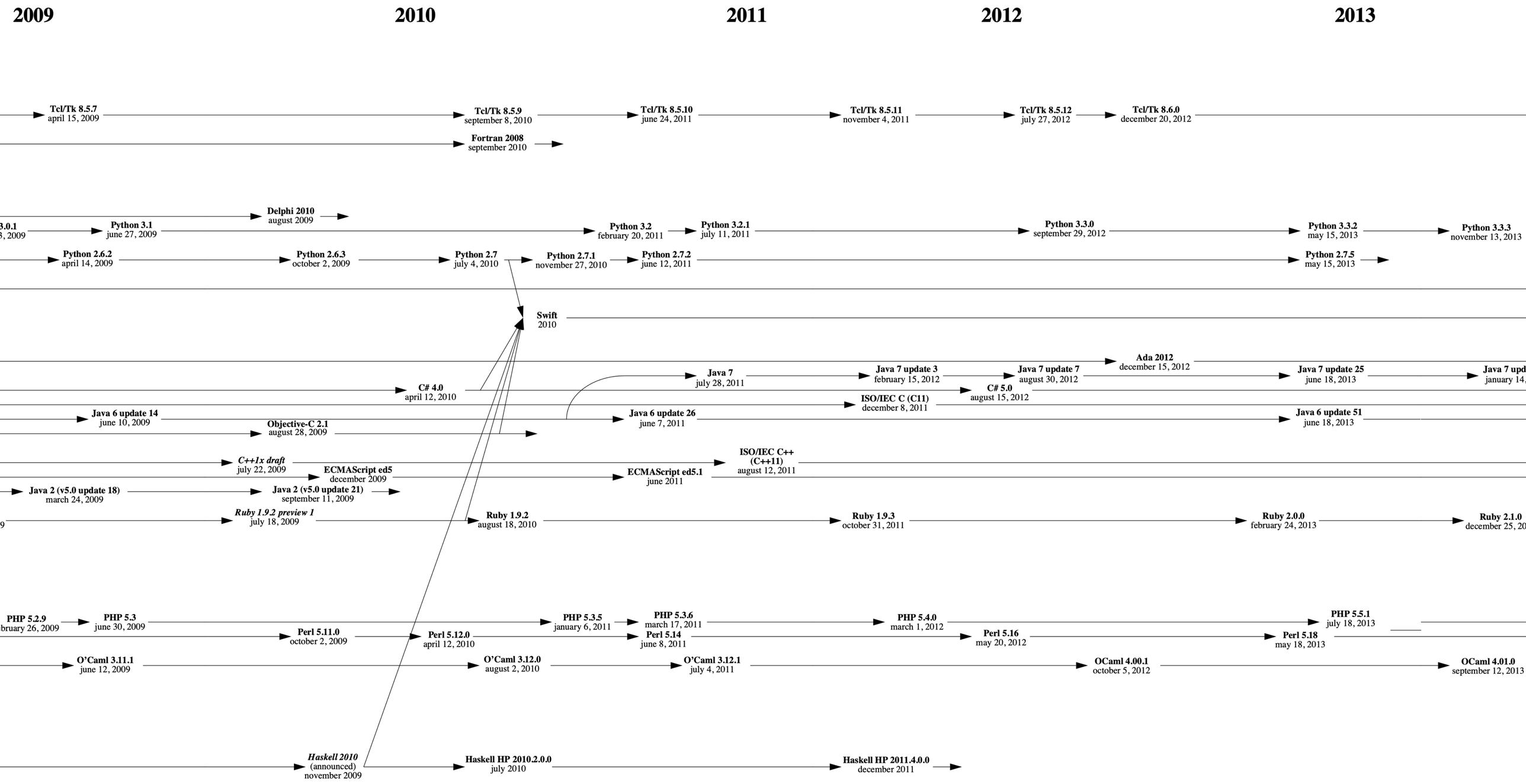
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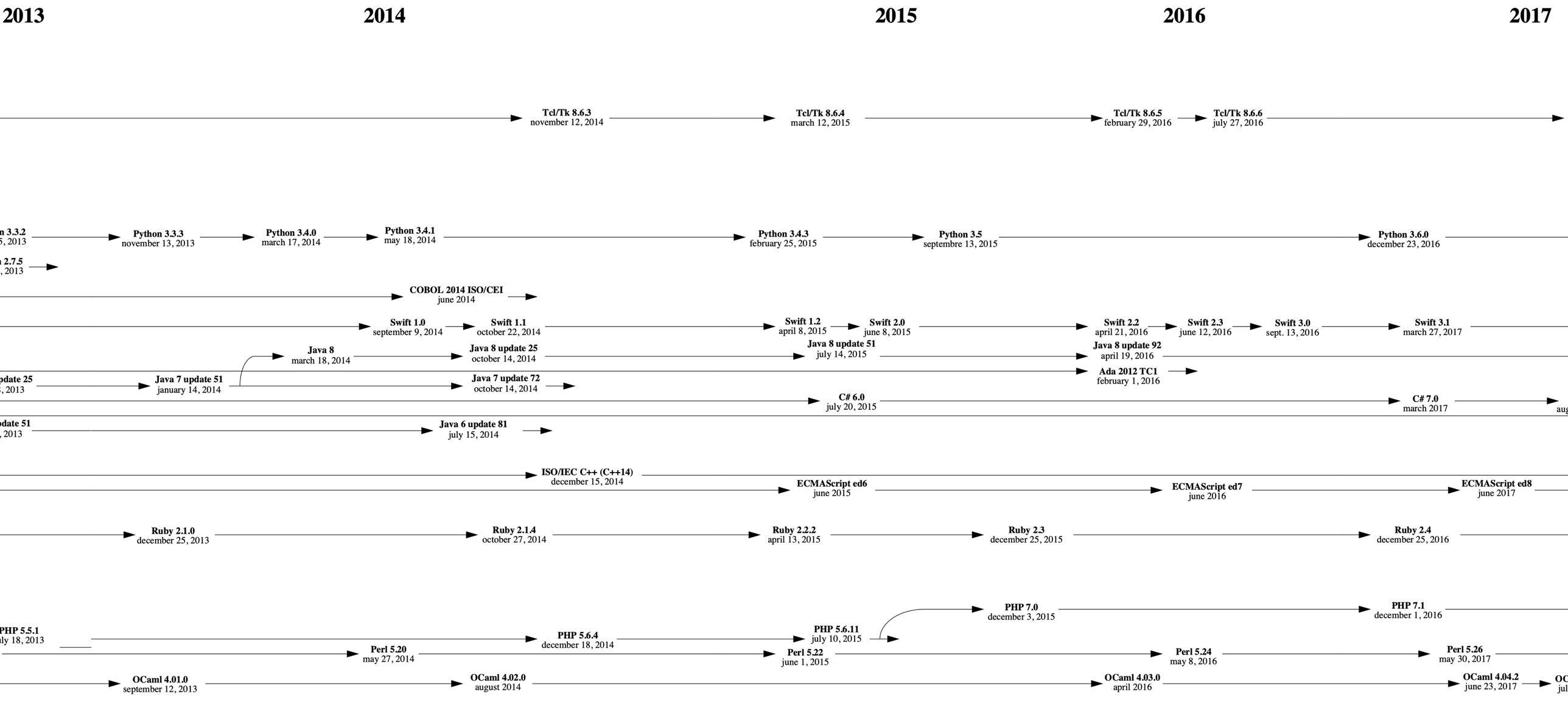
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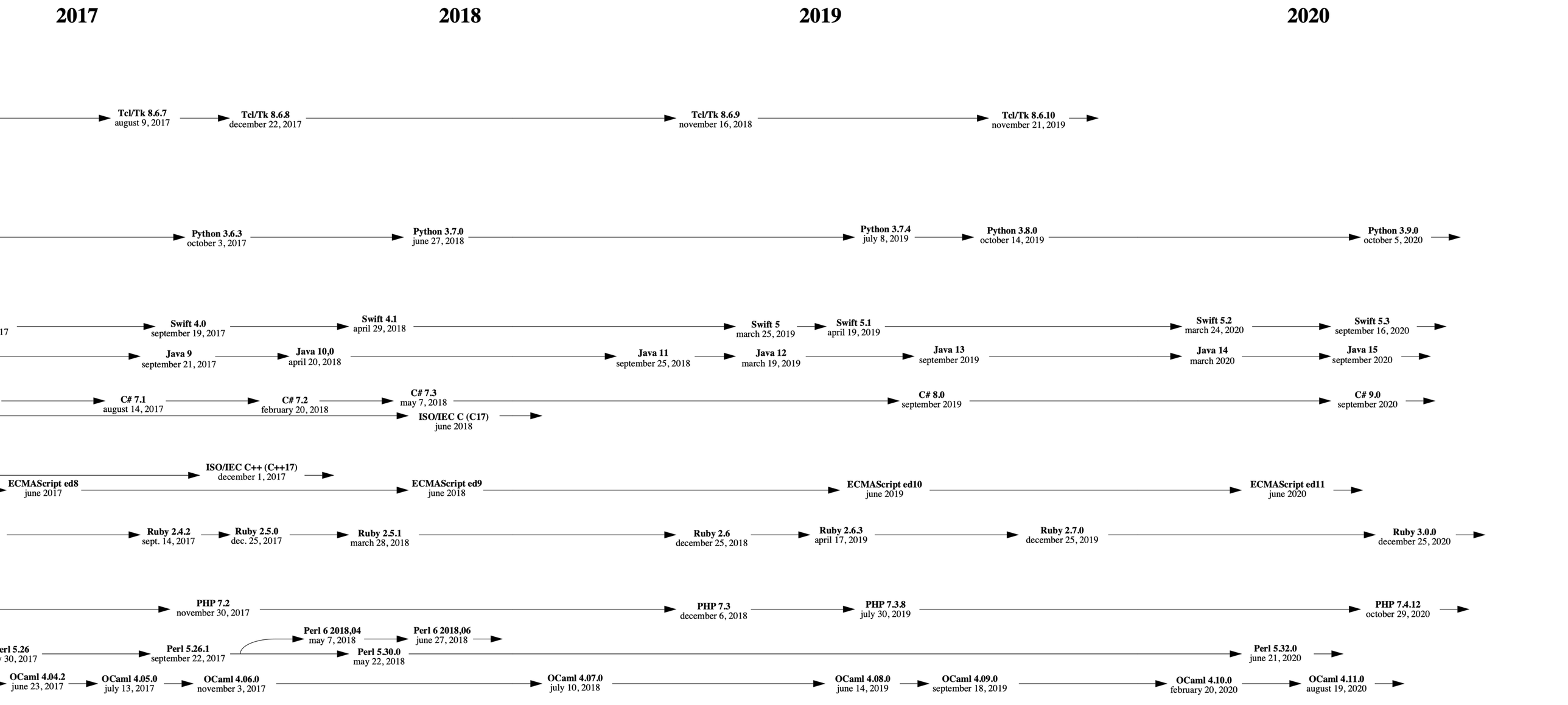
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august 19, 2020

Programming Paradigm

- Imperative (Think about *How*)
  - Procedures
  - Objects (classes)
  - State variables and Object fields
- Declarative (Think about *What*)
  - Functions
  - Predicates (logic)
  - Signals (reactive)
  - Events
  - Variables (mathematical definition)