A Brief (and Pretty Incomplete) History of Programming Languages

Stefan D. Bruda

CS 403, Fall 2024

History of programming languages

Prehystory

- Cuneiform writing used in the Babylon, founded by Hammurabi around 1790 BC
  - poems, stories, contracts, records, astronomy, math

Famous Babylonian math tablet (Plimpton 322) involving Pythagorean triples, $a^2 + b^2 = c^2$ – with a mistake! (or bug)

  - Weird math (base 60!)
    - two characters to express a (base-60) digit
    - decimal point not specified (must be figured out from context)

Written language to describe computational procedures

A cistern.
The length equals the height.
A certain volume of dirt has been excavated.
The cross-sectional area plus this volume comes to 110.
The length is 30. What is the width?
You should multiply the length, 30, by . . .
— Translation by Donald Knuth

- No variables
- Instead, numbers serve as a running example of the procedure being described
  - "This is the procedure"
- Programming is among the earliest uses to which written language was put
  - Programming languages design has tried to get as close to that as possible from the very beginning. . .

Algorithms

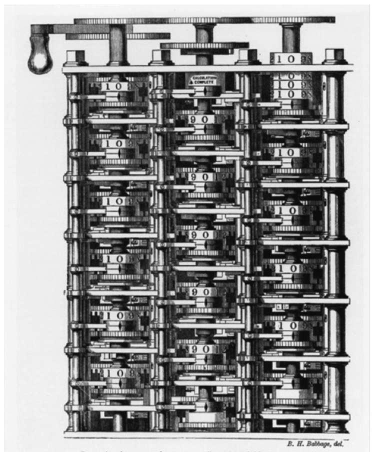
- Abū ’Abdallāh Muḥammad ibn Mūsā al-Khwārizmī, or Mohammed Al-Khorezmi for short (Baghdad, 780–850)
  - One little book: “The Compendious Book on Calculation by Completion and Balancing”
    - Compilation and extension of known rules for solving quadratic equations and other problems
    - Used as a mathematics text in Europe for eight hundred years
  - The book is considered the foundation of algebra
  - Invention of the notions of algorithms and data structures
- Earlier algorithms:
  - Euclid (300 BC): an algorithm for computing the GCD of two numbers
  - Eratosthenes (about same time): one of the most efficient algorithms for finding small primes (the sieve of Eratosthenes)
- Alexander de Villa Dei (1220): Canto de Algorismo = algorithms in Latin verse
- Natural language (even poetry!) plus math rather than programming languages

The first programming environments

- Jacquard loom (early 1800s) translated card patterns into cloth designs
- Charles Babbage’s Analytical Engine (1830s & 40s)
  - First programmer: Augusta Ada King, Countess of Lovelace (today commonly known as Ada Lovelace)

The engine can arrange and combine its numerical quantities exactly as if they were letters or any other general symbols; and in fact might bring out its results in algebraic notation, were provision made.

  - Programs were punched cards containing data and operations



B. H. Babbage, del.

Impression from a woodcut of a small portion of Mr. Babbage's Difference Engine No. 1, the property of Government, at present deposited in the Museum at South Kensington.
It was commenced 1823.
This portion put together 1833.
The construction abandoned 1842.
This plate was printed June, 1853.
This portion was in the Exhibition 1862.

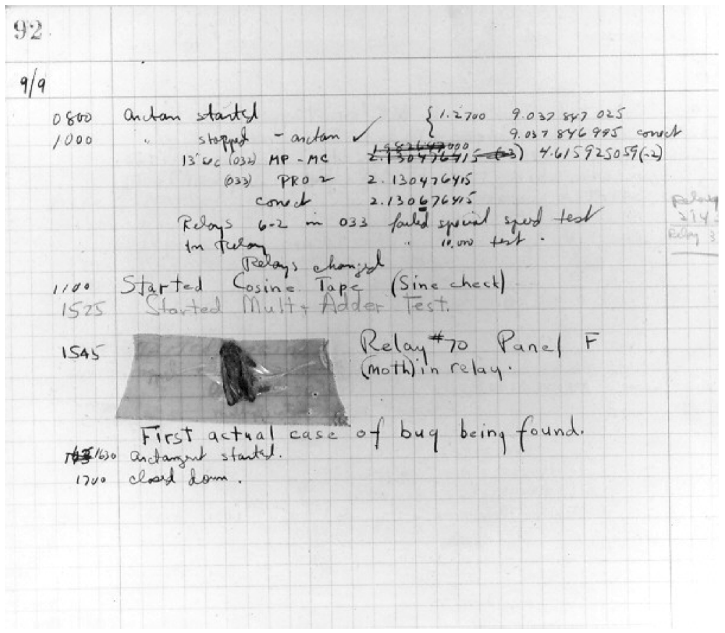
The 1940s: von Neumann and Zuse

- Harvard Mark I (1943) – Howard Aiken (IBM), Grace Hopper (Navy) → first electro-mechanical computer
  - Harvard Mark II: First computer bug
- ENIAC (1946) – Presper Eckert, John Mauchly (U. Penn.) → First electronic computer
- Programming was manual, with switches and cables
- John von Neumann led a team that built computers with stored programs and a central processing unit (as we know them today)
- Konrad Zuse designed the first programming language as we know it (Plankalkul = program calculus)
  - In Germany, in isolation because of the war; work finally published in 1972
  - Advanced data type features: floating point, arrays, records
  - Invariants for correctness
  - Rather cumbersome notation

$$A[7] := 5 \times B[6] \quad \rightarrow \quad \begin{array}{c|ccccc l} & 5 & * & B & \Rightarrow & A & \\ V & & & 6 & & 7 & \text{(subscripts)} \\ S & & & 1.n & & 1.n & \text{(data types)} \end{array}$$

  - Never implemented

The first computer bug!



92

9/9

0800 Anctan started
1000 " stopped - anctan ✓ {1.2700 9.037 847 025
9.037 846 995 correct
13" uc (032) MP - MC ~~1.982147000~~ ~~2.130476415~~ ~~(-3)~~ 4.615925059(-2)
(033) PRO 2 2.130476415
correct 2.130676415
Relays 6-2 in 033 failed special speed test
In Relay " 11,000 test .
Relays changed
1100 Started Cosine Tape (Sine check)
1525 Started Mult + Adder Test.
1545 Relay #70 Panel F
(moth) in relay.
First actual case of bug being found.
~~1630~~ 1630 Antangent started.
1700 closed down.

The 1950s: The first programming languages

- FORTRAN (1957, John Backus)
  - FORmula TRANslator – designed for scientific programming
  - Many new features over time: FORTRAN II, FORTRAN IV, FORTRAN 66, FORTRAN 77 (structured programs, char's), Fortran 90 (arrays, modules), Fortran 2003 (objects), Fortran 2008 (concurrent programming)
  - Very efficient compilation into fast machine code
- COBOL (1960, Grace Hopper)
  mathematical programs should be written in mathematical notation, data processing programs should be written in English statements — G. Hopper, 1953
  - Committee sponsored by US Department of Defence
  - Biggest contribution was the idea that programs should be written in a way that is easily understood
  - Adopted widely by businesses for record-keeping applications
  - Record structure, separation of data from execution part, versatile formatting of output using "pictures"
  - ANSI standards (1968, 1974, 1985)

FORTRAN example

```
   IMPLICIT INTEGER (A-Z)
   DIMENSION ORD(N),POPLST(2,20)
   INTEGER X,XX,Z,ZZ,Y
   INTEGER A(N)
   NDEEP=0
   U1=N
   L1=1
   DO 1 I=1,N
1  ORD(I)=I
2  IF (U1.LE.L1) RETURN
3  L=L1
   U=U1
4  P=L
   Q=U
   X=A(ORD(P))
   Z=A(ORD(Q))
   IF (X.LE.Z) GO TO 5 ....
5
```

COBOL example

```
ENVIRONMENT DIVISION.
CONFIGURATION SECTION.
SOURCE-COMPUTER. IBM-4381.
OBJECT-COMPUTER. IBM-4381.

DATA DIVISION.
WORKING-STORAGE SECTION.
01 INPUT-FIELD.
05 INPUT-VALUE PIC 99 VALUE ZERO.
01 CALCULATION-FIELD.
05 SUM-VALUE      PIC 9(03) VALUE ZERO.
05 AVERAGE-VALUE PIC 9(03)V99 VALUE ZERO.
01 OUTPUT-FIELD.
05 EDIT-FIELD PIC ZZ9.99 VALUE ZERO.

PROCEDURE DIVISION.
1000-MAIN.
       PERFORM 2000-INPUT-ADD 10 TIMES.
       DIVIDE 10 INTO SUM-VALUE GIVING AVERAGE-VALUE.
2000-INPUT-ADD. ...
```

The 1950s: The first languages (cont'd)

- Algol 60
  - General, expressive language; most current imperatives are derivatives
  - Introduced many modern concepts

structured programming	reserved keywords	type declarations
recursion	stack	call-by-value
user defined types	free-format	dynamic arrays

  - Stack-based run time environment
  - Great success and also great failure (ahead of its time, too complex, lack of I/O, lack of support from IBM) → entrenchment of Fortran
- LISP (John McCarthy, MIT)
  - LISt Processing → the main data structure is the (singly linked) list
  - Untyped, messy language, but good for problems we solve by trial and error (quick prototyping) → used in many AI applications
  - Historically inefficient on Von Neumann machines
  - Main processing unit: the recursive function → influenced the modern functional languages such as ML, Miranda, Haskell
  - Contemporary variants include Common Lisp, Scheme, Emacs Lisp

ALGOL EXAMPLE

```
procedure Absmax(a) Size:(n, m) Result:(y) Subscripts:(i, k);
    value n, m;
    array a;
    integer n, m, i, k;
    real y;
comment The absolute greatest element of the matrix a, of size
  n by m is transferred to y, and the subscripts of this element
  to i and k;
begin
    integer p, q;
    y := 0; i := k := 1;
    for p:=1 step 1 until n do
    for q:=1 step 1 until m do
        if abs(a[p, q]) > y then
            begin y := abs(a[p, q]);
            i := p; k := q
            end
end Absmax
```

LISP EXAMPLE

```
(defun mapcar (fun list)
  "Applies FUN on every element of LIST and returns the
   list of results (iterative version)."
  (let ((results nil))
    (dolist (x list)
      (setq results (cons (apply #'fun x) results)))
    (reverse results)))

(defun mapcar (fun list)
  "Applies FUN on every element of LIST and returns the
   list of results (recursive version)."
  (cons (apply #'fun (car list))
        (mapcar fun (cdr list))))
```

THE 1960S: AN EXPLOSION IN LANGUAGES

- Hundreds of languages were developed
- PL/1 (1964)
  - Combined features of FORTRAN, COBOL, Algol 60 and more!
  - Translators were slow, huge, and unreliable
  - Some say it was ahead of its time...
- Algol 68 → still ahead of its time!
- Simula (or what would be called today Object-oriented Algol)
- BASIC
- etc.

THE 1970S: SIMPLICITY, ABSTRACTION, STUDY

- Algol-W then Pascal (Nicklaus Wirth and C.A.R.Hoare) → small, simple, efficient (reaction against the 60s), ideal for teaching
- C (Dennis Ritchie)
  - Constructed as a portable assembler to build Unix for various architectures
  - But also has modern features (structured programming, data structures, etc.)
  - The primary API for Unix (Mac OS, Linux, etc.) is still C!
- Euclid (University of Toronto, 1977)
  - Main goal → formal program verification
  - extends Pascal to include abstract data types
- Scheme (1978, MIT) → simplified, cleaner Lisp

C example

```
#include <stdio.h>
main(t,_,a)
char*a;
{return!0<t?t<3?
main(-79,-13,a+
main(-87,1-_,
main(-86, 0, a+1 )
+a)):
1,
t<_?
main(t+1, _, a )
:3,
main ( -94, -27+t, a )
&&t == 2 ?_
<13 ?
main ( 2, _+1, "%s %d %d\n" )
:9:16:
t<0?
t<-72?
main( _, t,
"@n'+,#'/*{}w+/w#cdnr/+,{}r/*de}+,/*{*+,/w{%+,/w#q#n+,/#{l,+,/n{n+,/+#n+,/#;\
#q#n+,/+k#;*+,/'r :'d*'3,}{w+K w'K:'+}e#';dq#'l q#'+d'K#!/+k#;\
q#'r}eKK#}w'r}eKK{nl]'/#;#q#n'){)#}w'){){nl]'/+#n';d}rw' i;# ){nl]!/n{n#'; \
r{#w'r nc{nl]'/#{l,+'K {rw' iK{;[{nl]'/w#q#\
\
n'wk nw' iwk{KK{nl]!/w{%'l##w#' i; :{nl]'/*{q#'ld;r'}{nlwb!/*de}'c ;;\
{nl'-{}rw]'/+,}##'*}#nc,',#nw]'/+kd'+e}+;\
#'rdq#w! nr'/ ') }+}{rl#'{n' ')# }'+}##(!!/")
:
t<-50?
_==*a ?
putchar(31[a]):
main(-65,_,a+1)
:
main((*a == '/') + t, _, a + 1 )
:
0<t?
main ( 2, 2 , "%s")
```

The 1980s: Consolidation & new directions

- ML → mostly functional language (like Lisp) with cleaner (math-like) syntax
- Prolog (Université Aix Marseille)
  - PROgrammation en LOGique / PROgramming in LOGic → describes the problem at hand as known facts and inference rules
  - Notable industrial uses: IBM Watson, Apache UIMA, and the... Buran space plane
- Objects 'r' Us:
  - Smalltalk → the purest example of object-oriented language
  - C++ → extend a popular language (C) with strongly typed object system
  - Eiffel → object-oriented Pascal

The 1990s and 200s

- 1990s
  - Java → eliminate the non-object-oriented features of C++
  - Haskell → purely functional programming language

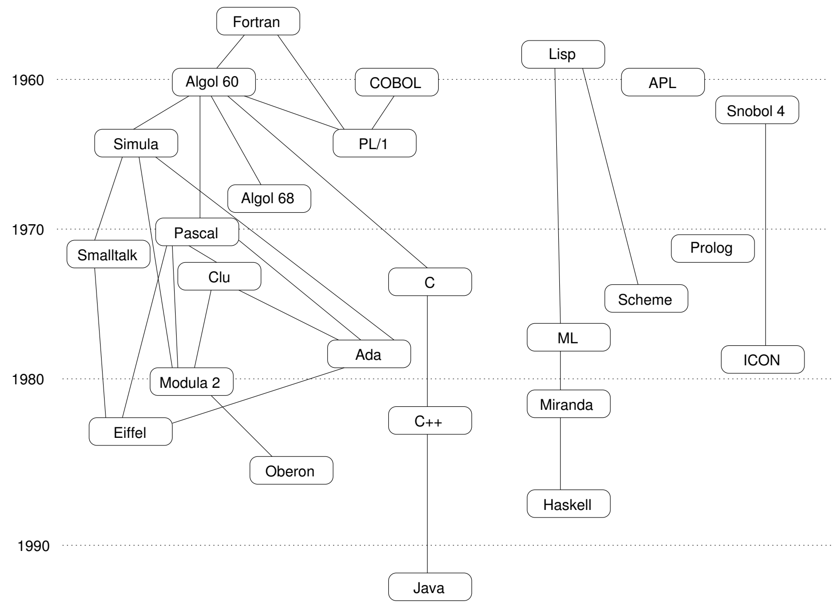
```
quicksort [] = []
quicksort (x:xs) = quicksort [y|x <- xs, y < x] ++ [x] ++
                   quicksort [y|x <- xs, y >= x]
```

- 2000s
  - Multi-paradigm language (procedural, object-oriented, functional, etc.)
    - First mainstream such a language: Python
  - Languages for the Web
    - Java applets
    - Languages within Web pages (PHP, server-side includes)
  - Emphasis on cross-platform development
    - Develop on PC, run on cell phones, game consoles, and toasters

Where are we now

- Computing devices are ubiquitous, and so is the Internet and Web
- C and C++ are the most widely used system programming languages
- Java had peaked... and then came Android
- Most students learn C / C++ or Java
- Web 2.0 programming (PHP, etc.)
- COBOL and Java are used for business applications
- Fortran is the main language on supercomputers
  - We already have Object-Oriented Fortran!
  - C++ is growing
- Several non-mainstream (but cleaner) languages rising (Ruby, Python, Haskell) → but who knows what the future has in store
  - Object-Oriented COBOL?

Chronology



Brainf**k

- A Brainf**k program has an implicit byte pointer, called “the pointer”, which is free to move around within an array of 30,000 bytes, initially all set to zero
- The pointer is initialized to point to the beginning of this array
- The Brainf**k programming language consists of eight commands, each of which is represented as a single character

`>`	Increment the pointer
`<`	Decrement the pointer
`+`	Increment the byte at the pointer
`-`	Decrement the byte at the pointer
`.`	Output the byte at the pointer
`,`	Input a byte and store it in the byte at the pointer
`[`	Jump past the matching `]` if the byte at the pointer is zero
`]`	Jump to the matching `[`

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