

CS 403: A Brief (and Pretty Incomplete) History of Programming Languages

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- “Prehistory”
- The 1940s: von Neumann and Zuse
- The 1950s: The first programming language
- The 1960s: An explosion in programming languages
- The 1970s: Simplicity, abstraction, study
- The 1980s: Consolidation and new directions
- The 1990s: The explosion of the World Wide Web
- The 21st century

- 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. . .

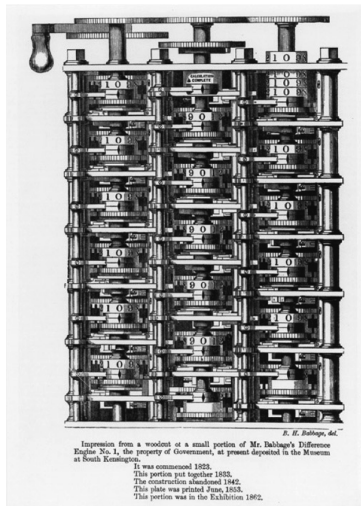


- Abū 'Abdallāh Muḥammad ibn Mūsā al-Khwārizmī, or **Mohammed Al-Khorezmi** for short (Baghdad, 780–850 BC)
 - One little book: “The Compendious Book on Calculation by Completion and Balancing”
 - Compilation and extension of known rules for solving quadratic equations and other problems
 - Used as a 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**
- Other early 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 AD): Canto de Algorismo = algorithms in Latin verse
- Natural language (even poetry!) plus math rather than programming languages

- **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**





- 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 processor (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

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

- **Never implemented**

THE FIRST COMPUTER BUG!



92.

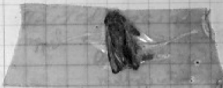
9/9

0800 Andam started { 1.2700 9.037 847 025
 1000 " stopped - andam ✓ 9.037 846 985 correct
 1300 (032) MP-MC 2.130476415 (2) 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 Multi-Adder Test.

1545  Relay #70 Panel F
 (moth) in relay.

First actual case of bug being found.

1630 Andam started.
 1700 closed down.

Relay 214
 Relay 3



- **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)



```
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
```



```
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.  ...
```



- **Algol 60**

- General, expressive language; most current imperatives are derivatives
- Introduced many modern concepts
 - structured programming reserved keywords type declarations
 - recursion stack dynamic arrays call-by-value
 - user defined types free-format
- **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)

- LISP 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



```
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
    end
  end
end Absmax
```



```
(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))))
```



- 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.



- **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


```
#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}'/k+d'+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")
/*...*/
```



- **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 spacecraft
- 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



• 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

- **Python** → multi-paradigm language (procedural, object-oriented, functional, etc.)
- **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



- 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?



- Strange languages definitely exist
- Case in point: **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 [

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

CHRONOLOGY

