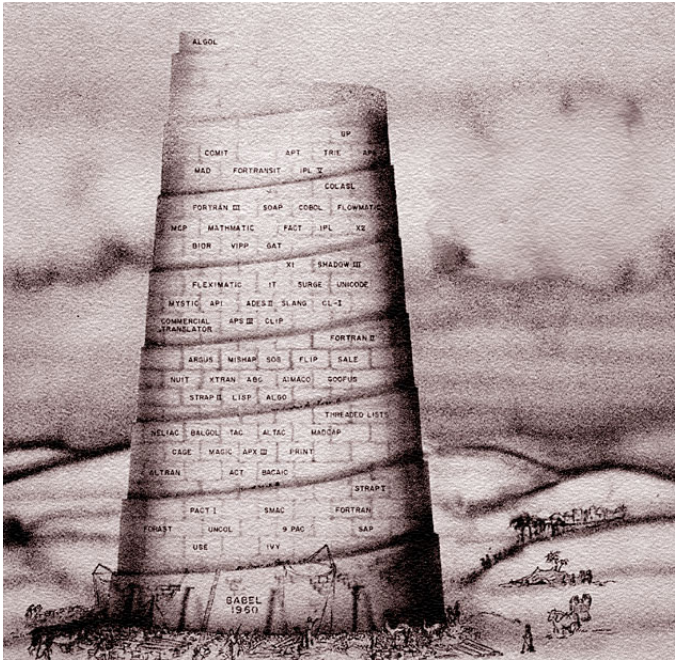
Typology of programming languages

~ Early Languages ~

The Tower of Babel



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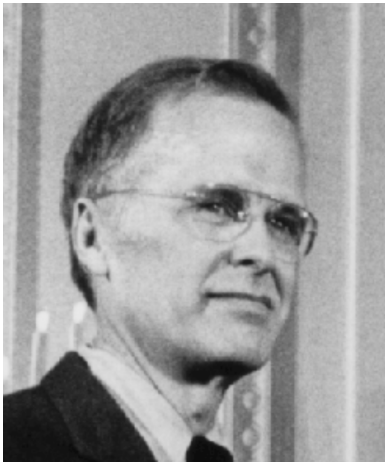
IBM Mathematical Formula Translator system

Fortran I, 1954-1956, IBM 704, a team led by John Backus.



IBM 704 (1956)

IBM Mathematical Formula Translator system

The main goal is user satisfaction (economical interest) rather than academic.
Compiled language.

- a single data structure : arrays
- comments
- arithmetics expressions
- DO loops
- subprograms and functions
- I/O
- machine independence

FORTRAN's success

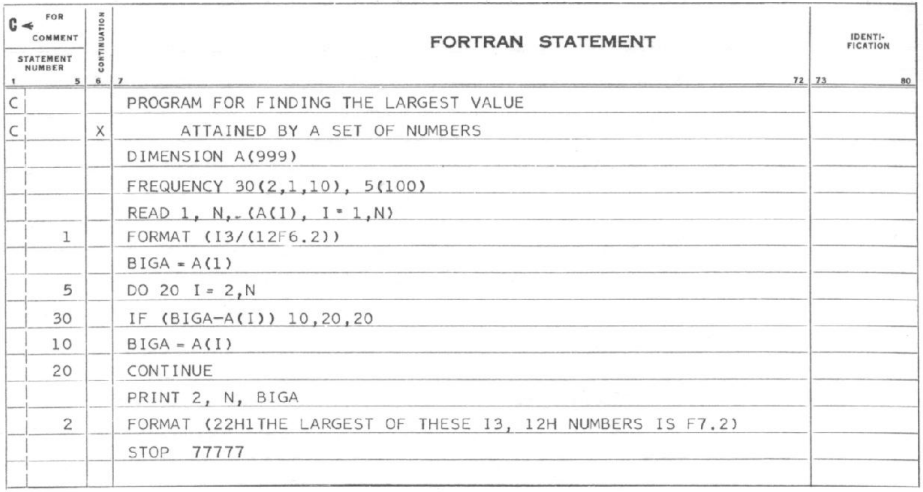
Because:

- programmers productivity
- easy to learn
- by IBM
- the audience was mainly scientific
- simplifications (e.g., I/O)

FORTRAN I

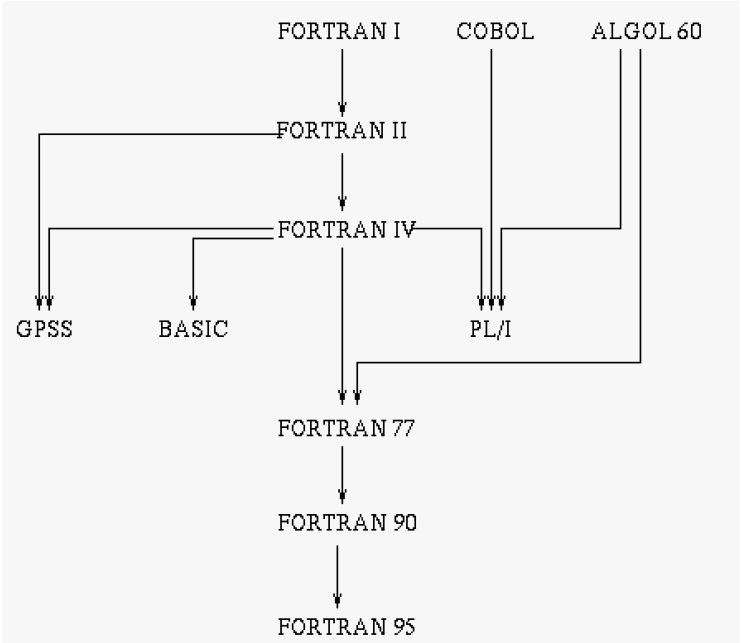
```
C       FIND THE MEAN OF N NUMBERS AND THE NUMBER OF
C       VALUES GREATER THAN IT
        DIMENSION A(99)
        REAL MEAN
        READ(1,5)N
 5      FORMAT(I2)
        READ(1,10)(A(I),I=1,N)
 10     FORMAT(6F10.5)
        SUM=0.0
        DO 15 I=1,N
 15        SUM=SUM+A(I)
        MEAN=SUM/FLOAT(N)
        NUMBER=0
        DO 20 I=1,N
           IF (A(I) .LE. MEAN) GOTO 20
           NUMBER=NUMBER+1
 20     CONTINUE
        WRITE (2,25) MEAN,NUMBER
 25     FORMAT(11H MEAN = ,F10.5,5X,21H NUMBER SUP = ,I5)
        STOP
```

Fortran on Cards



C ← FOR COMMENT STATEMENT NUMBER 1 5	CONTINUATION 6	FORTRAN STATEMENT 7 72	IDENTIFICATION 73 80
C		PROGRAM FOR FINDING THE LARGEST VALUE	
C	X	ATTAINED BY A SET OF NUMBERS	
		DIMENSION A(999)	
		FREQUENCY 30(2,1,10), 5(100)	
		READ 1, N, (A(I), I = 1,N)	
1		FORMAT (I3/(12F6.2))	
		BIGA = A(1)	
5		DO 20 I = 2,N	
30		IF (BIGA-A(I)) 10,20,20	
10		BIGA = A(I)	
20		CONTINUE	
		PRINT 2, N, BIGA	
2		FORMAT (22H1THE LARGEST OF THESE I3, 12H NUMBERS IS F7.2)	
		STOP 77777	

Fortrans


FORTRAN I
COBOL
ALGOL 60
FORTRAN II
FORTRAN IV
GPSS
BASIC
PL/I
FORTRAN 77
FORTRAN 90
FORTRAN 95

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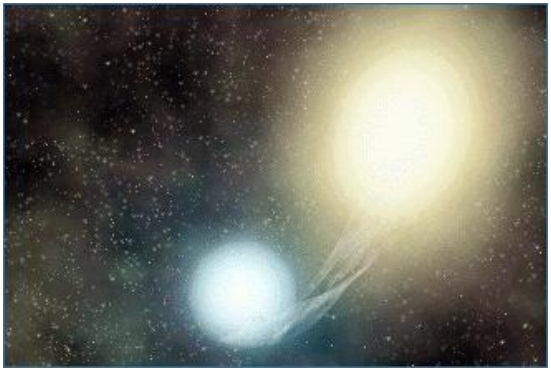
ALGOL, Demon Star, Beta Persei, 26 Persei



ALGOL 58

Originally, IAL, International Algebraic Language.

1. Usable for algorithm publications in scientific reviews
2. As close as possible to the usual mathematical notations
3. Readable without assistance
4. Automatically translatable into machine code

Meeting between 8 Americans and Europeans in Zurich. ALGOL 58.

ALGOL 58

- IAL was considered ”unspeakable and pompous acronym”
- Introduced the fundamental notion of compound statement
  - restricted to control flow only
  - not tied to identifier scope
- Used during 1959 for publication
- Primary contribution was to later languages: a basis for JOVIAL Quick, MAD, and NELIAC.
- Early compromise design soon superseded by ALGOL 60

JOVIAL

- ”Jules Own Version of the International Algorithmic Language.”
- Developed to write software for the electronics of military aircraft by Jules Schwartz in 1959.
- Runs the Advanced Cruise Missile, B-52, B-1, and B-2 bombers, C-130, C-141, and C-17 transport aircraft, F-15, F-16, F-18, and F-117 fighter aircraft, LANTIRN, U-2 aircraft, E-3 Sentry AWACS aircraft, Special Operations Forces, Navy AEGIS cruisers, Army Multiple Launch Rocket System (MLRS), Army UH-60 Blackhawk helicopters, ..

ALGOL 60

Figure: John Mac Carthy, Fritz Bauer, Joe Wegstein. Bottom row: John Backus, Peter Naur, Alan Perlis

ALGOL 60: Novelties

- Use of BNF to describe the syntax
- Informal semantics
- Block structure
- Dynamic arrays
- Advanced control flow (`if`, `for`...)
- Recursivity

ALGOL 60: One syntax, three lexics

Reference language (used in the ALGOL-60 Report)

a[i+1] := (a[i] + pi x r^2) / $6.02_{10}23$;

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ALGOL 60: One syntax, three lexics

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$a_{i+1} \leftarrow \{a_i + \pi \times r^2\}/6.02 \times 10^{23}$;

Hardware representations – implementation dependent

```
    a[i+1] := (a[i] + pi * r^2) / 6.02E23;
or  a(/i+1/) := (a(/i/) + pi * r ** 2) / 6,02e23;
or  A(.I+1.) .= (A(.I.) + PI * R 'POWER' 2) / 6.02'23.,
```

ALGOL 60: For Loops BNF

for loop syntax

```
<for statement> ::= <for clause> <statement>
                  | <label>: <for statement>

<for clause> ::= for <variable> := <for list> do

<for list> ::= <for list element>
             | <for list> , <for list element>

<for list element>  ::= <arithmetic expression>
   | <arithmetic expression> step <arithmetic expression>
                            until <arithmetic expression>
   | <arithmetic expression> while <Boolean expression>
```

ALGOL 60: For Loops

for step until

```
for i := 1 step 2 until N do
      a[i] := b[i];
```

for while

```
for newGuess := Improve (oldGuess)
      while abs (newGuess - oldGuess) > 0.0001 do
   oldGuess := newGuess;
```

for enumerations

```
for days := 31,
      if mod( year, 4 ) = 0 then 29 else 28,
      31, 30, 31, 30, 31, 31, 30, 31, 30, 31 do
   . . .
```

ALGOL 60: For Loops

`for` complete

```
for i := 3, 7,
      11 step 1 until 16,
      i / 2 while i >= 1,
      2 step i until 32 do
        print (i);
```

ALGOL 60: For Loops

- FORTRAN was occupying too much room
- Richer than FORTRAN, so more difficult
- IBM tried to impose ALGOL, but clients refused, and even threatened IBM
- FORTRAN compilers were more efficient and smaller
- No standardized I/O

ALGOL 60

```
begin
  comment The mean of numbers and the number of greater values;
  integer n;
  read(n);
  begin
    real array a[1:n];
    integer i, number;
    real sum, mean;
    for i := 1 step 1 until n do read (a[i]);
    sum := 0;
    for i := 1 step 1 until n do sum := sum + a[i];
    mean := sum / n;
    number := 0;
    for i := 1 step 1 until n do
      if a[i] > mean then
        number := number + 1;
    write ("Mean = ", mean, "Number sups = ", number);
  end
end
```

ALGOL 60: Legacy

- block,
- call by value, call by name,
- typed procedures,
- declaration scope,
- dynamic arrays,
- own variables,
- side effects,
- global and local variables,
- primary, term, factor,
- `step`, `until`, `while`, `if then else`,
- bound pair,
- display stack technique,
- thunks,
- activation records,
- recursive descent parser.

> *Here is a language so far ahead of its time that it was not only an improvement on its predecessors but also on nearly all its successors.*
>
> –
>
> *C.A.R. Hoare*

ALGOLW

Niklaus Wirth, 1966:

- Agregates (records, structures)
- References (hence lists, trees, etc.)
- Split `for` into `for` and `while`
- Introduction of `case` (`switch`)
- Call by value, result, value-result
- New types `long real`, `complex`, `bits`
- Introduction of `assert`
- String processing functions

Niklaus Wirth

ALGOL 68 Samples

Assignments

```
real twice pi = 2 * real pi = 3.1415926;
```

Complex Expressions

```
(int sum := 0; for i to N do sum +:= f(i) od; sum)
```

Procedures

```
proc max of real (real a, b) real:
  if a > b then a else b fi;
```

Ternary Operator

```
proc max of real (real a, b) real: (a > b | a | b);
```

ALGOL 68 Samples

Arrays, Functional Arguments

```
proc apply (ref [] real a, proc (real) real f):
  for i from lwb a to upb a do a[i] := f(a[i]) od;
```

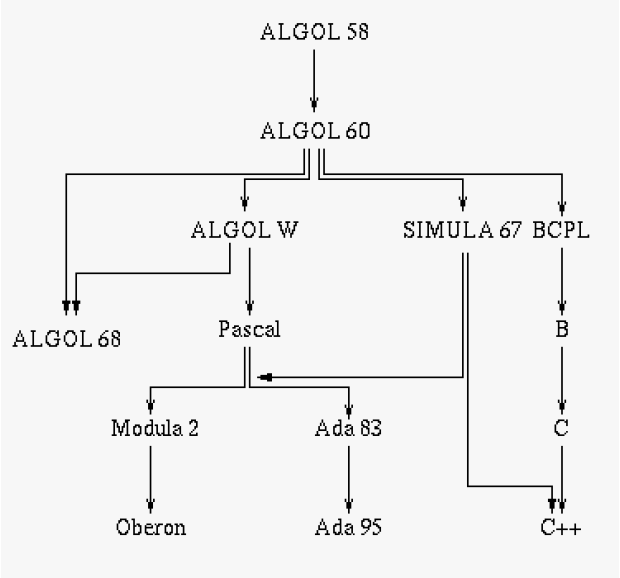
User Defined Operators

```
prio max = 9;

op max = (int a,b) int: (a>b | a | b);
op max = (real a,b) real: (a>b | a | b);
op max = (compl a,b) compl: (abs a > abs b | a | b);

op max = ([]real a) real:
   (real x := - max real;
    for i from lwb a to upb a
       do (a[i]>x | x:=a[i]) od;
    x);
```

Niklaus Wirth



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Grace Murray, December 9, 1906 – January 1, 1992

Captain Grace Murray-Hopper (1976)

Rear Admiral Grace Murray-Hopper

Commodore Grace Murray-Hopper/Reagan (1983)

Photo # NH 96926 President Reagan congratulates Commodore Hopper

Quotes from Grace Murray Hopper

> *Life was simple before World War II. After that, we had systems.*

Quotes from Grace Murray Hopper

> *Life was simple before World War II. After that, we had systems.*

> *In pioneer days they used oxen for heavy pulling, and when one ox couldn't budge a log, they didn't try to grow a larger ox.*
> *We shouldn't be trying for bigger computers, but for more systems of computers.*

Quotes from Grace Murray Hopper

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> *We shouldn't be trying for bigger computers, but for more systems of computers.*

> *Humans are allergic to change. They love to say, "We've always done it this way." I try to fight that. That's why I have a clock on my wall that runs counter-clockwise.*

Quotes from Grace Murray Hopper

> *A business' accounts receivable file is much more important than its accounts payable file.*

Quotes from Grace Murray Hopper

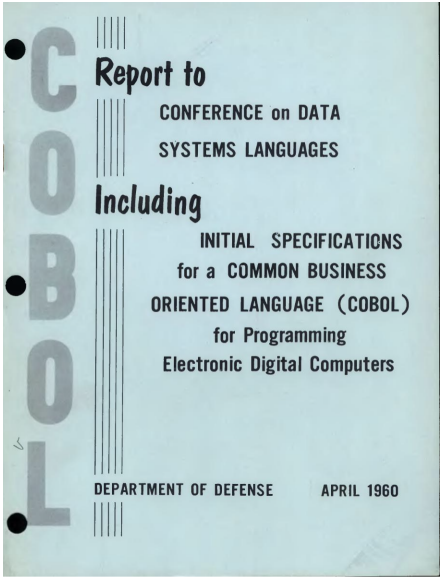
> *A business' accounts receivable file is much more important than its accounts payable file.*

> *We're flooding people with information. We need to feed it through a processor. A human must turn information into intelligence or knowledge. We've tended to forget that no computer will ever ask a new question.*

Grace Murray, December 9, 1906 – January 1, 1992

- Common Business Oriented Language, end of the 50's.
- The most used language worldwide for a long time.
- Imposed by the DOD, thanks to Grace Hopper:
  - to have a contract, a COBOL compiler was required,
  - any material bought on governmental funding had to have a COBOL compiler.
- A program is composed of divisions.

COBOL specification



COBOL

```
IDENTIFICATION DIVISION.

PROGRAM-ID. INOUT.

* Read a file, add infos
* to records, and save
* as another file.

ENVIRONMENT DIVISION.
INPUT-OUTPUT SECTION.
FILE-CONTROL.

SELECT INP-FIL ASSIGN TO INFILE.
SELECT OUT-FIL ASSIGN TO OUTFILE.
```

COBOL

```
DATA DIVISION.
FILE SECTION.

FD     INP-FIL
       LABEL RECORDS STANDARD
       DATA RECORD IS REC-IN.
01     REC-IN.
       05 ALPHA-IN PIC A(4).
       05 SP-CH-IN PIC X(4).
       05 NUM-IN   PIC 9(4).
FD     OUT-FIL
       LABEL RECORDS STANDARD
       DATA RECORD IS REC-OUT.
01     REC-OUT.
       05 ALPHA-OUT PIC A(4).
       05 SP-CH-OUT PIC X(4).
       05 NUM-OUT   PIC 9(4).
```

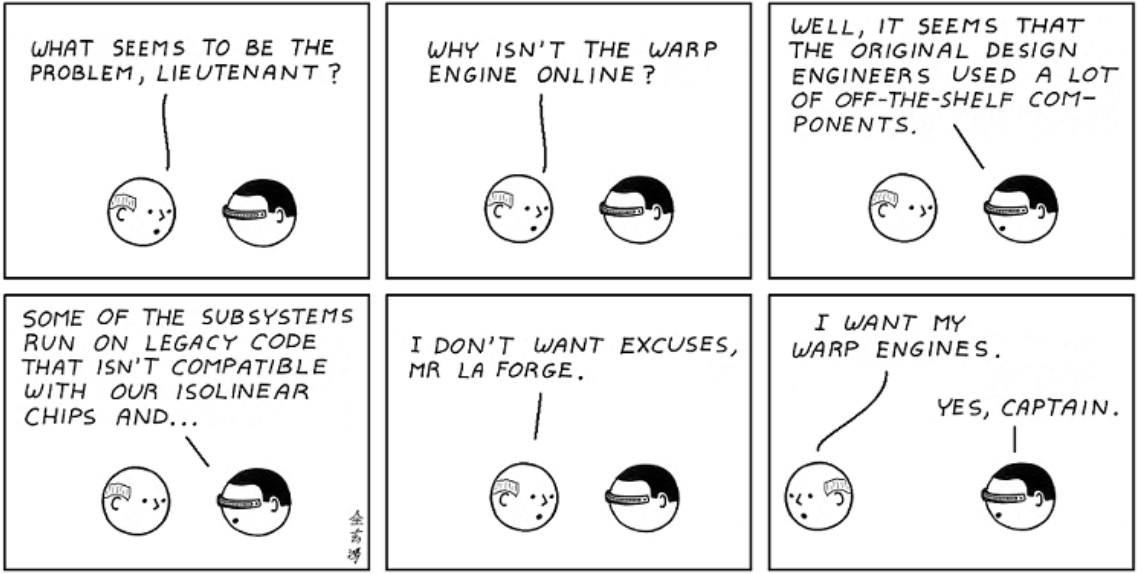
COBOL

```
WORKING-STORAGE SECTION.
01   EOF PIC X VALUE IS 'N'.

PROCEDURE DIVISION.
AA.
     OPEN INPUT INP-FIL
     OPEN OUTPUT OUT-FIL

     PERFORM CC
     PERFORM BB THRU CC
          UNTIL EOF = 'Y'

     CLOSE INP-FIL, OUT-FIL
     DISPLAY "End of Run"

     STOP RUN
```

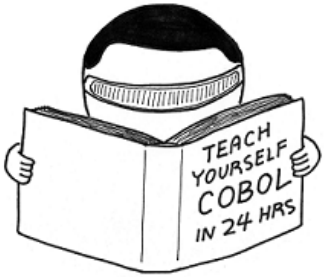
COBOL

> *The use of COBOL cripples the mind; its teaching should, therefore, be regarded as a criminal offense.*
>
> –
> *Edsger Dijkstra*

In the 24th century...



In the 24th century...



New technologies will come and go
but COBOL is forever.

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Kenneth E. Iverson

Quotes on APL

> *APL, in which you can write a program to simulate shuffling a deck of cards and then dealing them out to several players in four characters, none of which appear on a standard keyboard.*
>
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>
> *David Given*

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> *Edsger Dijkstra, 1968*

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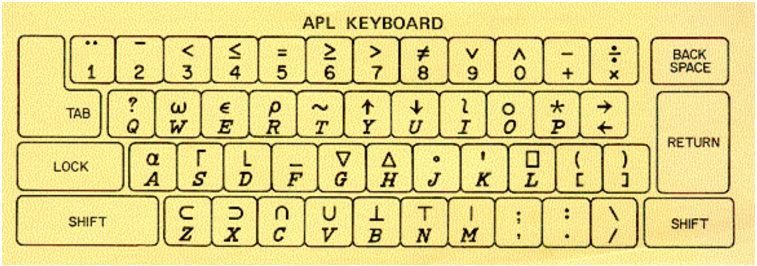
> *Edsger Dijkstra, 1968*

> *By the time the practical people found out what had happened; APL was so important a part of how IBM ran its business that it could not possibly be uprooted.*
>
> –
>
> *Micheal S. Montalbano, 1982*

APL Keyboard

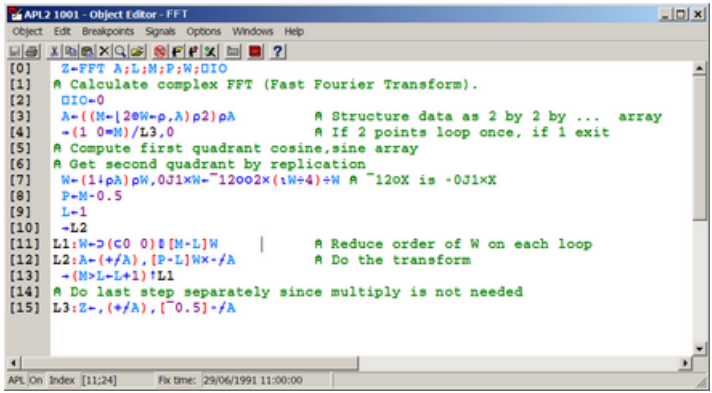


APL Program

Prime Numbers up to R

$$(\sim R \in R \circ . \times R)/R \rightarrow 1 \downarrow \iota R$$

APL IDE



video: smootlife-in-apl.mp4

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PL/I

Be able to address all the needs:

- scientific (floats, arrays, procedures, efficient computation)
- business (fixed points, fast asychronous I/O, string processing functions, search and sort routines)
- real time
- filtering
- bit strings
- lists

By IBM for IBM 360. “Includes” FORTRAN IV, ALGOL 60, COBOL 60 and JOVIAL. Introduction of ON, for exceptions.

PL/I Surprises

PL/I Surprises

PL/I Surprises

- No reserved keywords in PL/I.

```
IF IF = THEN THEN
THEN = ELSE
ELSE ELSE = IF
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- Abbrev.: DCL for DECLARE, ...

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- 25 + 1/3 yields 5.3333333333 while 25 + 01/3 behaves as expected...

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- 25 + 1/3 yields 5.3333333333 while 25 + 01/3 behaves as expected...
- this loop is executed zero times.

```
DO I = 1 TO 32/2,
Statements  END;
```

PL/I Surprises

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IF IF = THEN THEN
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```
DO I = 1 TO 32/2,
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```

- “Advanced” control structures

```
GOTO I,(1,2,3,92)
```

PL/I Surprises

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IF IF = THEN THEN
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Statements  END;
```

- “Advanced” control structures

```
GOTO I,(1,2,3,92)
```

PL/I uses

Implementation of MULTICS!

```
EXAMPLE : PROCEDURE OPTIONS (MAIN);
  /* Find the mean of n numbers and the number of
     values greater than it */
  GET LIST (N);
  IF N > 0 THEN
      BEGIN;
      DECLARE MEAN, A(N), DECIMAL POINT
              NUM DEC FLOAT INITIAL(0),
              NUMBER FIXED INITIAL (0)
      GET LIST (A);
      DO I = 1 TO N;
        SUM = SUM + A(I);
      END
      MEAN = SUM / N;
      DO I = 1 TO N;
        IF A(I) > MEAN THEN
          NUMBER = NUMBER + 1;
      END
      PUT LIST ('MEAM = ', MEAN,
                'NUMBER SUP = ', NUMBER);
END EXAMPLE;
```

Quotes on PLI

> *When FORTRAN has been called an infantile disorder, full PL/1, with its growth characteristics of a dangerous tumor, could turn out to be a fatal disease.*
>
> –
>
> *Edsger Dijkstra*

Quotes on PLI

> *Using PL/I must be like flying a plane with 7000 buttons, switches, and handles to manipulate in the cockpit. I absolutely fail to see how we can keep our growing programs firmly within our intellectual grip when by its sheer baroqueness, the programming language–our basic tool, mind you!–already escapes our intellectual control.*
> *And if I have to describe the influence PL/I can have on its users, the closest metaphor that comes to my mind is that of a drug.*
>
> –
>
> *Edsger Dijkstra*

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BASIC

Beginner's All-purpose Symbolic Instruction Code, J. Kemeny et T. Kurtz, 1965.
Made to be simple and interpreted (NEW, DELETE, LIST, SAVE, OLD, RUN).

```
 10 REM FIND THE MEAN OF N NUMBERS
 12 REM AND THE NUMBER OF VALUES
 14 REM GREATER THAN IT
 20 DIM A(99)
 30 INPUT N
 40 FOR I = 1 TO N
 50 INPUT A(I)
 60 LET S = S + A(I)
 70 NEXT I
 80 LET M = S / N
 90 LET K = 0
100 FOR I = 1 TO N
110 IF A(I) < M THEN 130
120 LET K = K + 1
130 NEXT I
140 PRINT "MEAN = ", M
150 PRINT "NUMBER SUP = ", K
160 STOP
170 END
```

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Pascal

Niklaus Wirth, end of the 60's.

- Keep the ALGOL structure,
  but obtain FORTRAN's performances.
- `repeat`, `until`.
- Enumerated types.
- Interval types.
- Sets.
- Records.
- No norm/standard.

Ada (83)

A command from the DOD in the 70's.
Embeded systems.

- Strawman, spec.
- Woodenman,
- Tinman, no satisfying language, hence a competition.
- Ironman,
- Steelman, Ada, the green language, wins. Jean Ichbiah, Honeywell-Bull.

Package, package libraries, rich control structures, `in`, `out`, `in out`, interruptions, exceptions, `clock`.

Modula-2, Oberon

Niklaus Wirth.
Modula-2 :

- Module, interface, implementation.
- Uniform syntax.
- Low level features
  (system programming).
- Processes, synchronization,
  co-routines.
- Procedure types.

Oberon : Inheritance.

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K. N. King / J. Ichbiah

K. N. King / A. Kay

K. N. King / D. Ritchie

K. N. King / B. Stroustrup

K. N. King / N. Wirth

Most Popular programming Languages

video: most-popular-1965-2019.mp4