Course Introduction

Programming Languages

CS 214

Welcome!

Welcome to CS 214:

Programming Language Concepts

On-line Course Materials and Syllabus:

http://cs.calvin.edu/courses/cs/214/

Programming Language (PL) History

PL history can be divided into *generations*:

- In the first generation, programming consisted of writing programs in *binary machine language*

```
0010 1011 1000 0000
0010 1111 1000 0100
0011 0011 1000 1000
```

Such programs were

- difficult to write
- prone to programmer errors
- difficult to debug

so people quickly sought a better way...

The Second Generation

To avoid having to program using binary operations, programmers developed *mnemonics* for the operations, and used *symbolic names* instead of memory addresses:

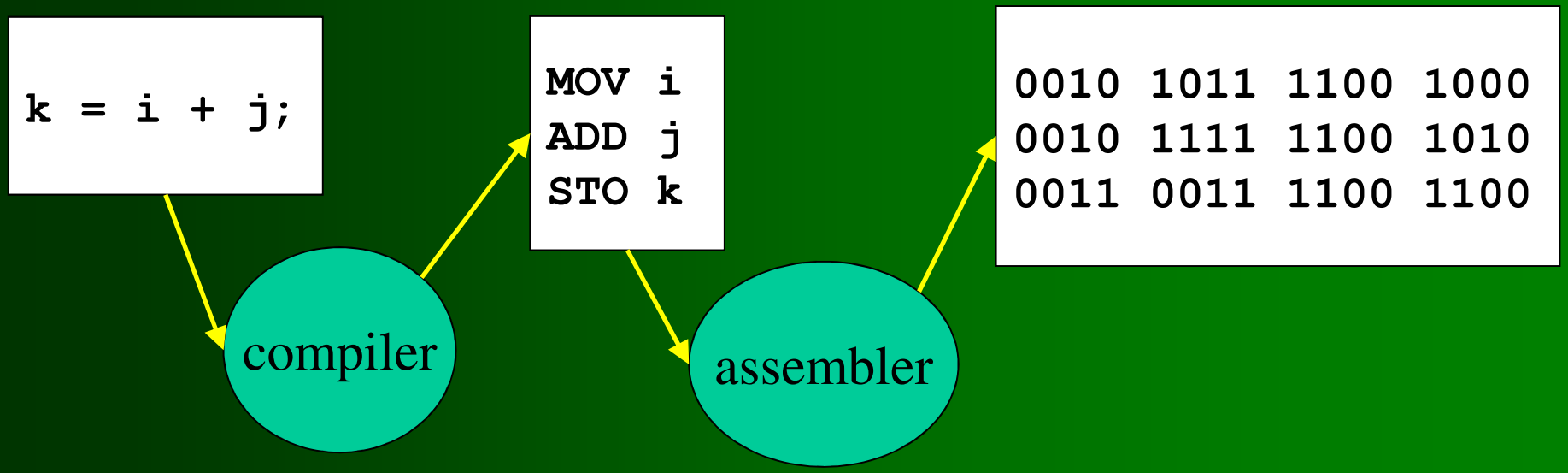
```
MOV → 0010 1011          I → 1000 0000
ADD → 0010 1111          J → 1000 0100
STO → 0011 0011          K → 1000 1000

      MOV I → 0010 1011 1000 0000
      ADD J → 0010 1111 1000 0100
      STO K → 0011 0011 1000 1000
```

The resulting *assembly languages* were the 2nd gen. PLs.

Assemblers are programs that translate assembly to binary.

The Third Generation

Assembly languages were still awkward and not portable, so Grace Hopper proposed *high level languages* (HLLs) that would hide/be independent of the machine-level details; plus a *compiler* to translate them into machine language:



HLLs are the 3rd generation of programming languages.

HLLs (1940s)

Between 1942 and 1945, Konrad Zuse designed *Plankalkül* for his Z-series of computers in Germany:

- Plan + kalkül = calculus (formal system) for planning
- The very first HLL, it included many advanced features:
  - Assignment statements (local variables only)
  - Conditional statements (and expressions)
  - Iteration (for loops, while loops)
  - Subroutines (non-recursive) and parameters (pass-by-value only)
  - Assertions
  - Exceptions
  - Data structures (arrays, tuples/records, graphs)
  - …
- Largely unknown in the west until 1970s, due to WW-II…

HLLs (50s)

In the west, there were no HLLs until the late 1950s:

- 1957: John Backus et al design *FORTRAN*
  - FORmula TRANslation; for scientific users
  - Subsequent versions in '58, '62, '77, '90, '95
- 1959: Grace Hopper et al design *COBOL*
  - Emphasized readability; for business users
  - Introduced If-Then-Else statement
- 1959: John McCarthy designs *Lisp*
  - LISt Processing; introduced the linked *list* as primitive type
  - First *functional* programming language (every op is a function)
  - Also introduced dynamic scope, garbage collection

HLLs (60s)

- 1960: Nicholas Wirth et al design *Algol-60*
  - ALGOrithmic Language: designed for encoding algorithms
  - Introduces *block structure*: basis for structured programming
  - Introduces *procedures*: basis for procedural programming
- 1964: Wirth designs *Algol-W* (CASE statement)
  - Kemeny and Kurtz design *BASIC*
  - Iverson designs *APL* (*multidimensional arrays, graphic symbols*)
- 1965: IBM designs *PL-1* (*multi-tasking, exceptions*)
- 1967: Nyquist & Dahl design *Simula*
  - SIMULAtion HLL; introduces *class* construct
  - Laid foundation for O-O programming

Edsgar Dijkstra Quotes

- "The use of COBOL cripples the mind; its teaching should, therefore, be regarded as a criminal offense."
- "It is practically impossible to teach good programming to students who have had prior exposure to BASIC, as potential programmers they are mentally mutilated beyond hope of regeneration."
- "APL is a mistake, carried through to perfection. It is the language of the future for the programming techniques of the past: it creates a new generation of coding bums."

HLLs (late 60s, early 70s)

- 1968: Wirth designs *Algol-68*
  - Introduces *If-Then-Elseif* statement; *pointer variables*
- 1970: Wirth designs *Pascal*
  - Consolidates Algol-x features into one simple language
- 1970: Ritchie designs *C* for OS implementation (Unix)
  - Provides direct hardware access, separate compilation/linking,…
  - AKA "high level assembly language" and "Fortran done right"
- 1972: Colmerauer, Roussel & Kowalski design *Prolog*
  - PROgramming LOGic; designed for logic programming
  - Logic/predicate-based HLL for programming *inferences*
  - First logic HLL; used in expert systems

HLLs (late 70s)

- 1977: Gordon & Milner design *ML* (MetaLanguage)
  - Hybrid HLL: functional, with inference rules (Prolog)
  - Allows linked ADTs to be defined without pointers (recursively)
  - AKA a "higher level language"
- 1979: Hoare designs *CSP*
  - Introduces support for concurrent programming
- 1980: Alan Kay et al design *Smalltalk* at Xerox PARC:
  - First pure object-oriented language (*inheritance*, *polymorphism*)
  - Program statements translated to byte code, not machine code
  - Introduces virtual machine to execute byte code
  - Functions replaced by *methods*, calls by *messages to objects*

HLLs (early 80s)

- 1980: Wirth designs *Modula-2*
  - Introduces the *module* - a container for types and operations
- 1981: DOD designs *Ada*
  - Algol-family HLL
  - Introduces *generic types*, task synchronization (*rendezvous*)
- 1983: May designs *Occam*
  - Concurrent HLL based on CSP
- 1983: LLNL designs *SISAL*
  - Concurrent HLL for array-processing on supercomputers
- 1984: Sussman & Abelson design *Scheme*
  - Simplified easier-to-use Lisp, with static scoping

HLLs (mid-late 80s)

- 1984: Jordan designs *The Force*
  - First HLL for programming SIMD (vector) multiprocessors
- 1986: Stroustrup designs *C++*
  - Hybrid language: (procedural) C with object-oriented features
  - Parameterized types via macro-substitution (templates)
- 1987: Wall designs *Perl*
  - Interpreted procedural language; features of C, sh, awk, sed, Lisp
- 1988: Wirth designs *Oberon*
  - Algol-family with features for OO and systems programming
- 1988: Mehrotra & van Rosendale design *Kali*
  - First language for programming MIMD multiprocessors

HLLs (early 90s)

- 1990: Hudak & Wadler design *Haskel*
  - Hybrid language: functional + OO features
- 1990: van Rossum designs *Python*
  - Scripting language; features from Perl, Scheme, Smalltalk, Tcl
  - Focus on readability, ease for the person instead of the machine
- 1991: Microsoft designs *Visual Basic*
  - BASIC with integrated support for building GUIs
  - Later versions add OO features (classes, etc.)
  - By 2000, VB controls are most-reused "objects" in the world
- 1993: *High Performance Fortran (HPF)* released
  - Fortran extended for SIMD and MIMD multiprocessors

HLLs (mid 90s)

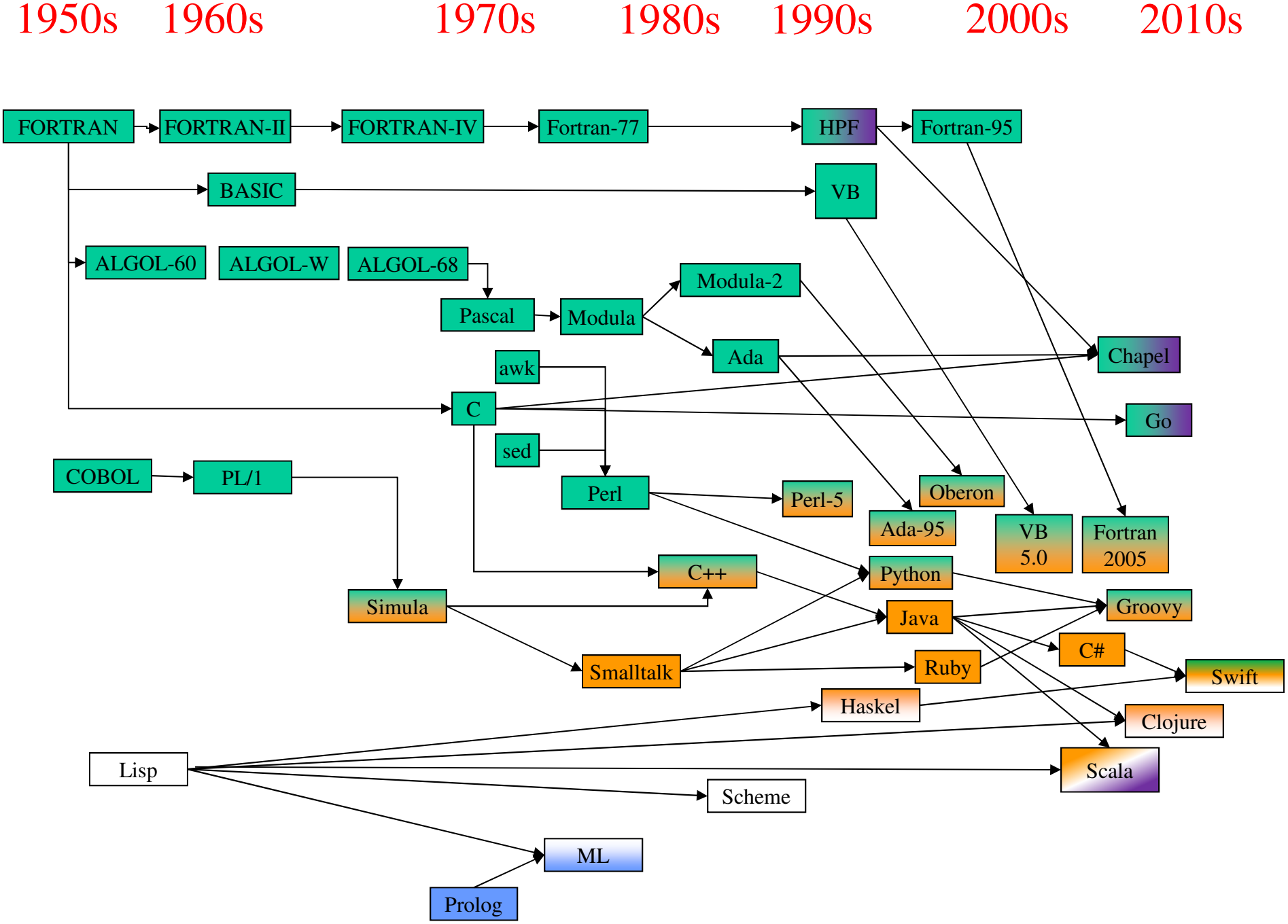
- 1994: *Perl-5* released
  - OO features added to Perl
- 1995: *Ada-95* released
  - OO features added to original Ada (renamed *Ada-8x*)
- 1995: Matsumoto releases *Ruby*
  - Fully OO scripting language; features from Perl, Python, …
  - Emphasis on making menial web-development tasks easy
- 1996: Gosling et al design *Java*
  - C++ syntax, Smalltalk philosophy
  - Extensive class library (networking, graphics, threads, etc.)
  - Provides Java Virtual Machine (JVM) for platform-independence
  - Support for both applications and applets (run via www-browser)

HLLs (2000s)

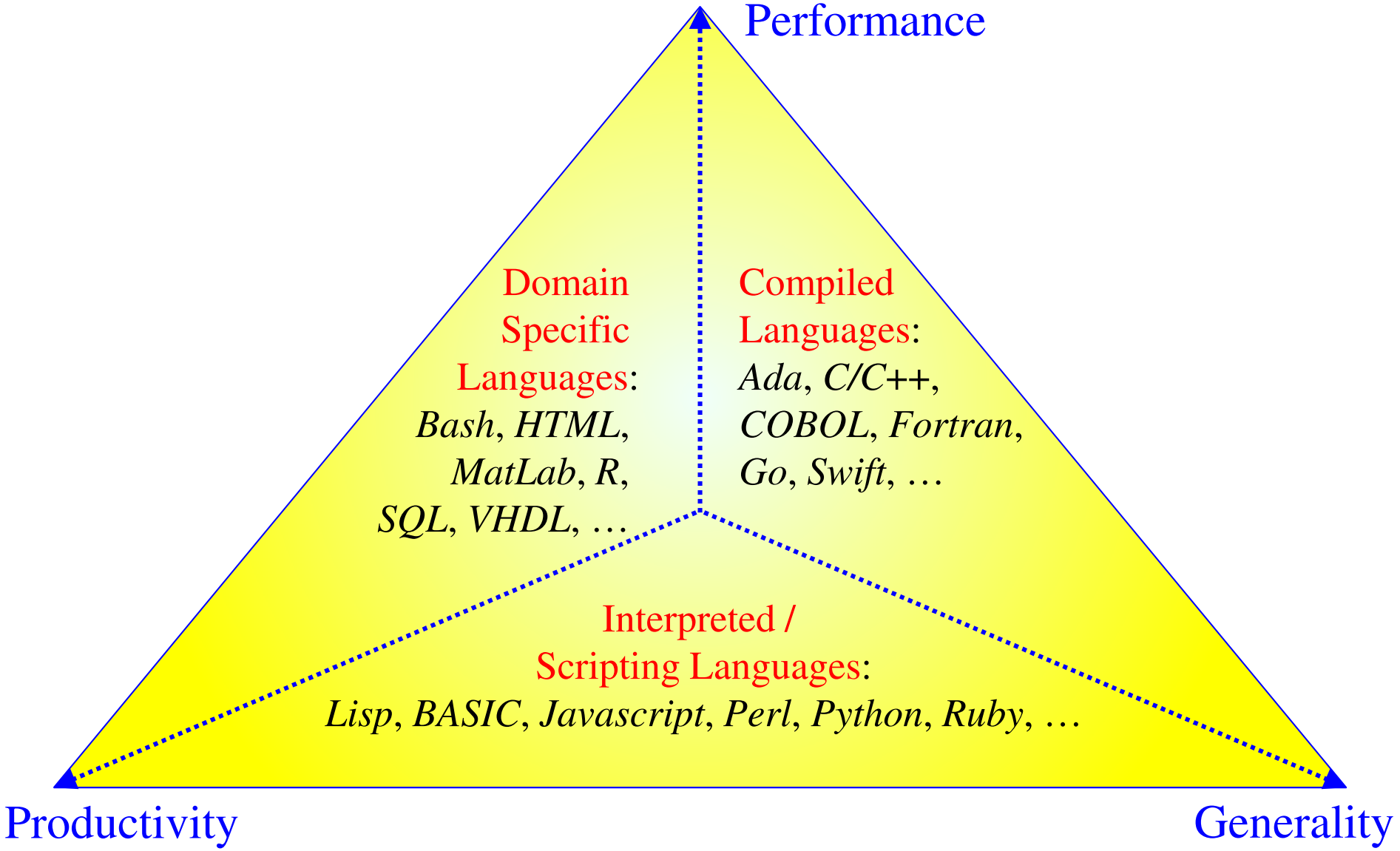
HLL development continues to this day…

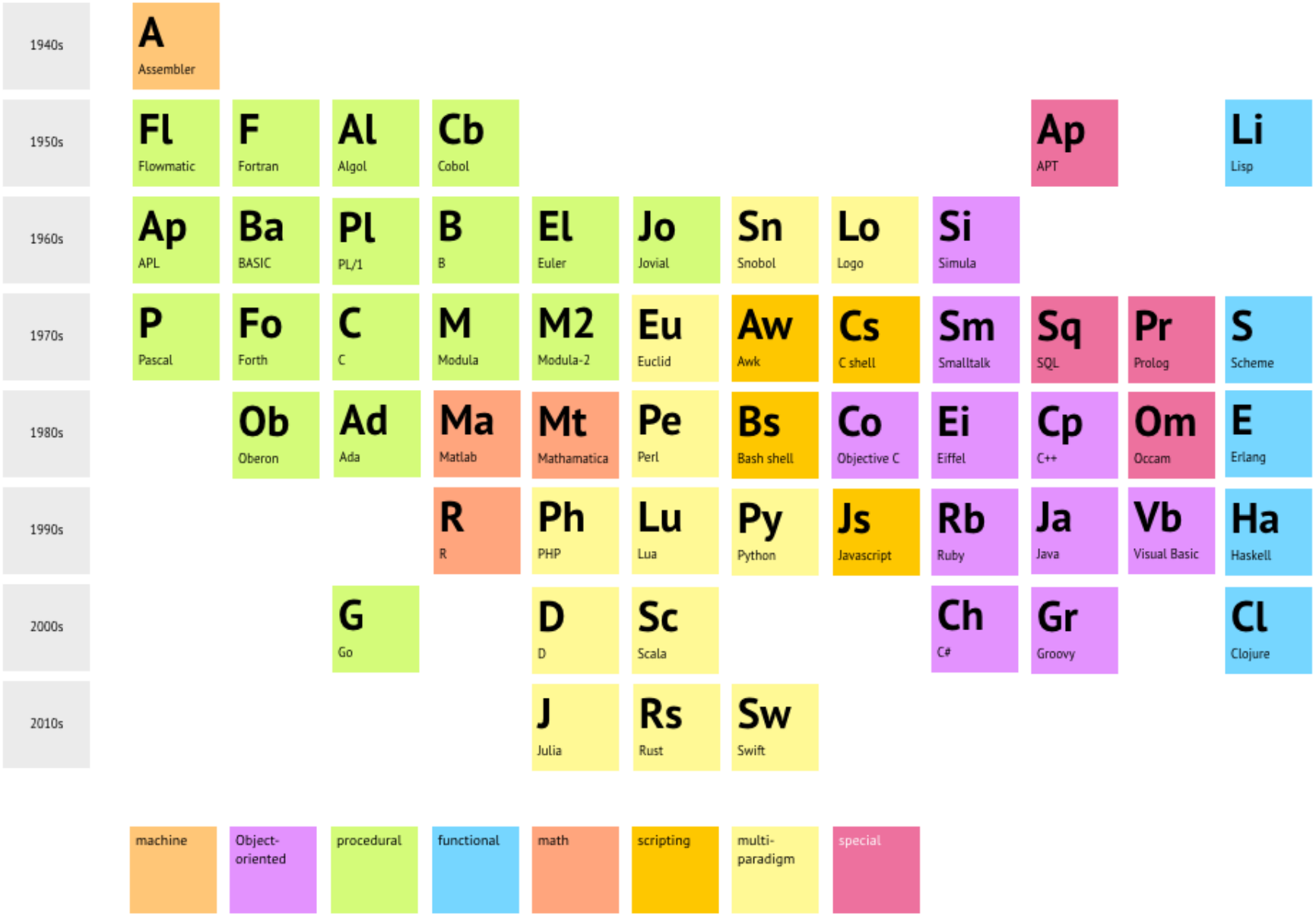
- 1995: *Javascript, PHP*
- 1996: *UML*
- 2000: *C#, R*
- 2004: *Scala*
- 2007: *Go, Groovy*
- 2009: *Clojure*
- 2010: *Chapel, Fortress, X10*
- 2012: *Julia*
- 2013: *Unified Parallel C*
- 2014: *Swift*
- …

… and *hundreds* of other languages along the way!


1950s
1960s
1970s
1980s
1990s
2000s
2010s
FORTRAN
FORTRAN-II
FORTRAN-IV
Fortran-77
HPF
Fortran-95
BASIC
VB
ALGOL-60
ALGOL-W
ALGOL-68
Pascal
Modula
Modula-2
Ada
Chapel
awk
C
Go
sed
COBOL
PL/1
Perl
Perl-5
Oberon
Ada-95
VB 5.0
Fortran 2005
C++
Python
Simula
Java
Groovy
C#
Smalltalk
Ruby
Swift
Haskel
Clojure
Lisp
Scala
Scheme
ML
Prolog

“Pick Two” Classification of HLLs





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Summary

Programming can be done in very different ways:

- *Imperative*: write blocks of *statements*
  - The Fortran- and Algol-families, Ada-8x, BASIC, COBOL, C, …
- *Functional*: write *functions*, pass *arguments*
  - The Lisp-family, ML, Haskell, …
- *Object-oriented*: build *objects*, send them *messages*
  - Smalltalk, Java, C++, Haskell, Ada-95, …
- *Concurrent*: build communicating *processes/threads/tasks*
  - CSP, Occam, Java, Ada, Erlang, Scala, Chapel, Go, Julia, ...
- *Logic*: write *inference rules*
  - Prolog, ML

These are known as the *five programming paradigms*.