Evaluating Programming Languages

How can we judge or compare languages?

Expressiveness

- Technically not interesting; nearly all languages are "Turing-complete."

Appropriateness to domain

- Scientific (numerical) computing
- Business applications
- Artificial intelligence
- Systems programming
- etc.

High-level goals for code

- Easily readable
- Easily writable
- Maintainable
- Efficient

Goals for languages

- Simplicity
- Uniformity (orthogonality)
- Modularity
- Clean syntax
- Maximizes explicit structure
- Clear execution model
- Efficient implementation model

Costs affected by programming language choice

Execution speed (& space)

Development time

- Program writing
- Compilation, testing, debugging
- (Training)

Maintenance time

- Program reading

Factors affecting programming language choice

Costs (as above)

Availability of implementations

Availability of trained programmers (should this matter?)

Politics

Inertia

FORTRAN 1954-58 John Backus (IBM)

Domain: Numerical computation

Features:

- Arithmetic expressions (evaluated using stack)
- Statements
- Bounded arrays
- Iterative control structures
- Subroutines (no recursion; call-by-reference; separate compilation (in FORTRAN II))
- Common blocks (and EQUIVALENCE declarations)
- I/O using FORMAT directives

Implementation model:

- Fixed run-time storage requirements
- Optimization of numerical computations

Still used very widely: FORTRAN IV, FORTRAN 77, FORTRAN 90, HPF
**ALGOL 60 1957-60 Committee**
(incl. Backus, McCarthy, Naur)

Domain: Numerical computation

Features:
- Carefully defined by “report”
- Syntax defined with BNF
- Block structure (stack-based implementation)
- Recursive subroutines
- Explicit type declarations
- Scope rules and dynamic lifetimes
- Relational & boolean expressions
- Call-by-value & call-by-name
- Dynamic Array Bounds

Never widely used in US; somewhat used in Europe.

Very influential on later languages.

“An improvement on nearly all its successors.” – Hoare

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**Pascal Family 1971- Niklaus Wirth**

Pascal 1971

Domain: General-purpose programming, education.

- Simplicity of language and implementation
- Rich type definition facility
- Structured programming methodology
- Suitable for proving programs correct

**Modula-2 1979-81**

- Modules for abstraction
- Systems programming facilities
- Procedure types

**Oberon, Oberon-2 1988-90, 1992**

- Further simplification!
- Addition of object-oriented features.

**Modula-3 1988-89**

- Separate development by DEC SRC.

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**Cobol 1959-61 DOD-led committee**

Domain: Business data processing

Features:
- Separate data description
- Record data structures
- File description/ manipulation
- English-language-like syntax (“Syntactic sugar”)
- Early standardization

Still used very widely.

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**Ada 1977-83 DOD-sponsored committee**
(Ichbiah)

Domain: Everything, but especially embedded systems.

Features:
- Focus on reliability, safety.
- Real-time control and multiprocessing.
- Programming support environments.
- Very large and verbose language.

Was mandated for much DOD work, but no more. Ada95 added object-oriented features.

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**C 1972-74 Dennis Ritchie (Bell Labs)**

Domain: Systems Programming; hacking of all kinds.

Implementation language for UNIX kernel and utilities

- Rich set of operators
- Terse syntax
- Easy machine access

Very successful; widely used in engineering and education

Standardized as **ANSI C**

**C++ 1980- Bjarne Stroustrup**

Domain: As C.

- Extended version of C.
- Direct support for abstract data types
- Object-oriented programming
- Large and very complex language

Used very widely.
Java  1995-  Arnold & Gosling (Sun)
Domain: Internet applet programming; as C++.
• Cut-down, cleaned-up version of C++.
• Automatic heap storage management (garbage collection).
• Type-safety and runtime memory security.
• Portable runtime environment (Java Virtual Machine).
Wildly hyped for network applications; may or may not take over C++ territory.

C#  2001-  Microsoft
• Very similar to Java (though supposedly independent).
• Common Language Runtime environment intended to support multiple source languages.

Visual Basic  1990’s  Microsoft
Domain: Customizing and extending MS Windows-based office and COM applications.
• Very loosely based on BASIC language developed in early ’60’s.
• Programs (especially user-interfaces) usually built using interactive visual program development environment.
• Often used to “glue” together existing code components.
• Supports rapid, “one-off” prototyping and large-scale system development.
• Conventional procedural language.
• Dynamic typing.
• Supports COM objects.
Used very widely in Microsoft environments.

LISP and Functional Languages
LISP  1959-60  John McCarthy (MIT)
Domain: Artificial intelligence; symbolic computing
Features:
• List processing
• “First-class” functions
• Extremely simple program syntax; programs can easily manipulate programs
• Dynamic typing
Many variants, including Common Lisp, Scheme; also related to
• Static but flexible typing
• Rich, orthogonal type system
• Module support
Haskell  1987-  Academic Committee
• Lazy (demand-driven) evaluation
• Pure functions