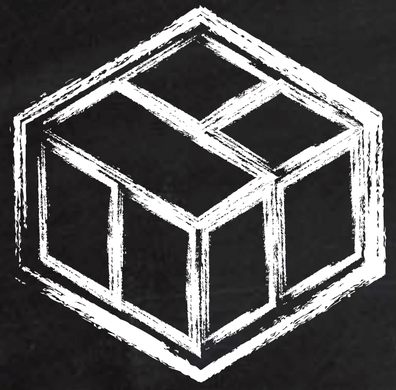

Architecting and Engineering Main Memory Database Systems in Modern C

Chapter 2
The C Language

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OTTO VON GUERICKE
UNIVERSITÄT
MAGDEBURG


Choosing a Programming Languages
THE RIGHT TOOL FOR THE TASK
VENDOR-LOCKIN VS OPEN
FAVORED SEMANTICS
THIRD-PARTY FUNCTIONALITY SUPPORT
PRODUCTIVE AND FAST DEVELOPMENT
PROJECT CONSTRAINTS
FAVORED SYNTAX
REALTIME REQUIREMENTS
APPLICATION VS SCRIPT VS SERICE VS SYSTEM
LEARNING CURVE
DOMAIN
EXPERIENCE & SKILLS
GOOD STANDARD LIBRARY
ECO-SYSTEM AND TOOL SUPPORT
LOW-LEVEL CONTROL
DESKTOP VS SERVER VS MOBILE
PROGRAMMING PARADIGM
LANGUAGE COMPLEXITY
LANGUAGE AGE
PORTABILITY (WEB, WIN, LINUX, CROSS PLATTFORM)
COMMUNITY SUPPORT
LANGUAGE FEATURES
Basic
Ruby
C
Dart
Python
Perl
Rust
Pascal
Kotlin
ActionScript
Scala
TypeScript
CUDA C
PL/SQL
Machine Code
C++
C#
bourne shell
R
QBasic
Java
Go
JavaScript
Windows PowerShell
Swift
Bytecode
Groovy
OpenCL
Assembler
Haskell
Swift
PHP
Object Pascal
Object Pascal
Lua
Lisp
PostScript
Objective-C
Smalltalk

Why did *you* choose to visit a course
having the words *engineering* and *C* in the title?

If we Choose C for DB Dev (Lecturers Personal Impression)

FAVORED SYNTAX

FAVORED SEMANTICS

THIRD-PARTY FUNCTIONALITY SUPPORT

VENDOR-LOCKIN VS OPEN

PROJECT CONSTRAINTS

DOMAIN

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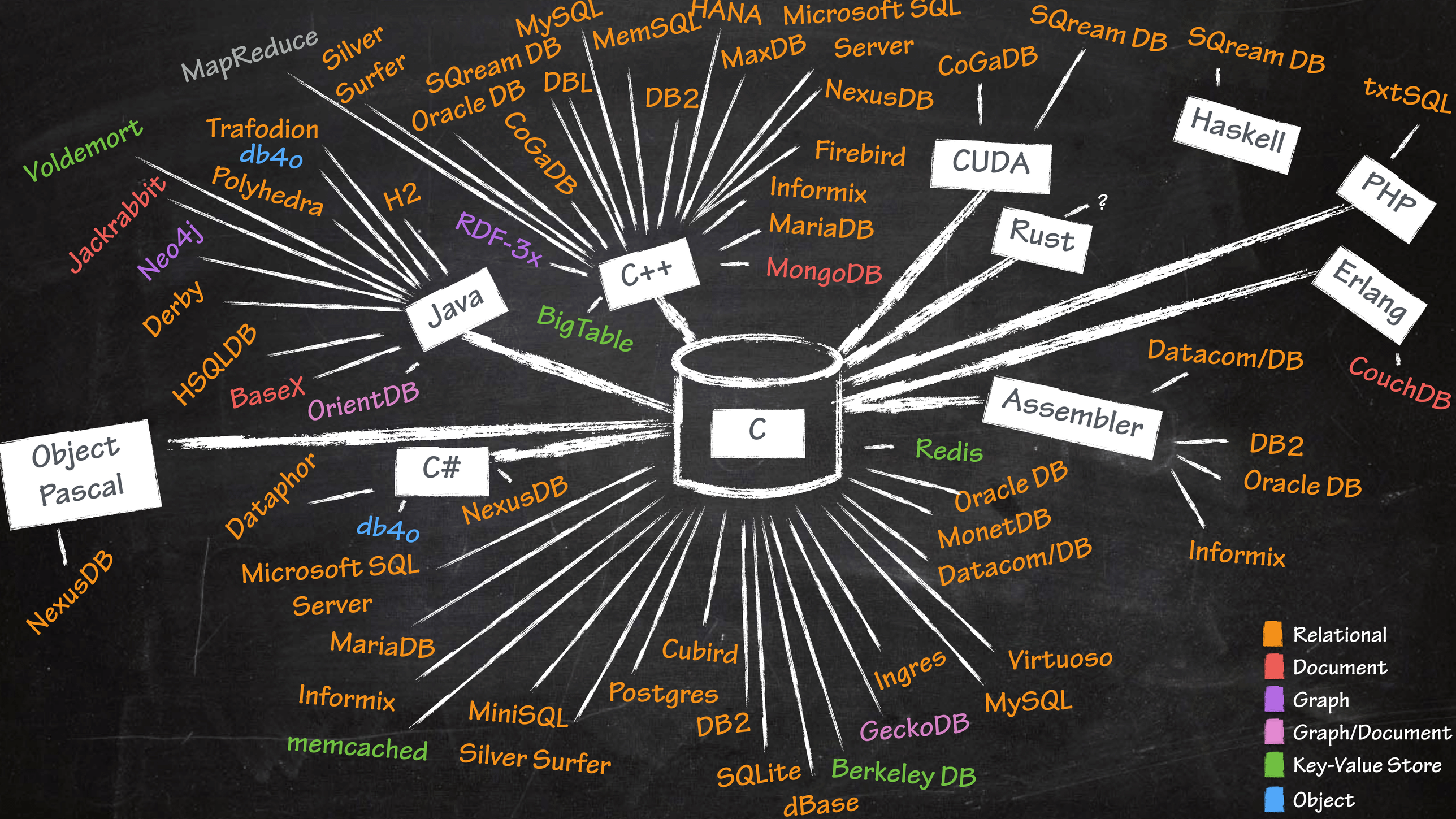
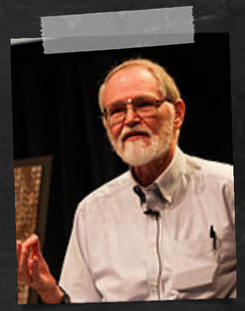
!


C
Java
C++
C#
Object Pascal
Assembler
Haskell
PHP
Erlang
CUDA
Rust
?
MapReduce
Silver Surfer
MySQL
SQream DB
Oracle DB
DBL
CoGaDB
MemSQL
HANA
DB2
MaxDB
Microsoft SQL Server
NexusDB
CoGaDB
SQream DB
SQream DB
txtSQL
Voldemort
Trafodion
db4o
Polyhedra
Jackrabbit
Neo4j
Derby
HSQLDB
BaseX
OrientDB
H2
RDF-3x
BigTable
Firebird
Informix
MariaDB
MongoDB
Datacom/DB
CouchDB
Redis
Oracle DB
MonetDB
Datacom/DB
DB2
Oracle DB
Informix
Dataphor
db4o
NexusDB
Microsoft SQL Server
MariaDB
Informix
memcached
MiniSQL
Silver Surfer
Cubird
Postgres
DB2
SQLite
dBase
Berkeley DB
Ingres
GeckoDB
Virtuoso
MySQL
NexusDB
Relational
Document
Graph
Graph/Document
Key-Value Store
Object

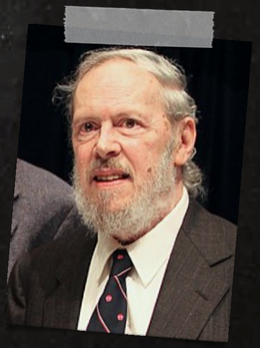
INTRODUCTION

Design Goals of C

Kenneth Thompson,
Creator of C



Brian W. Kernighan,
Creator of C



Dennis Ritchie,
Creator of C

- Small language complexity: limit to most important control structures and data types
- Efficient compiler: which takes little time for translation
- Minimal runtime support: compiler and platform-specific standard library & runtime
- Platform portability*: abstraction from hardware and operating system
- Highly efficient programs: compiling to programs with high execution performance and small memory footprint

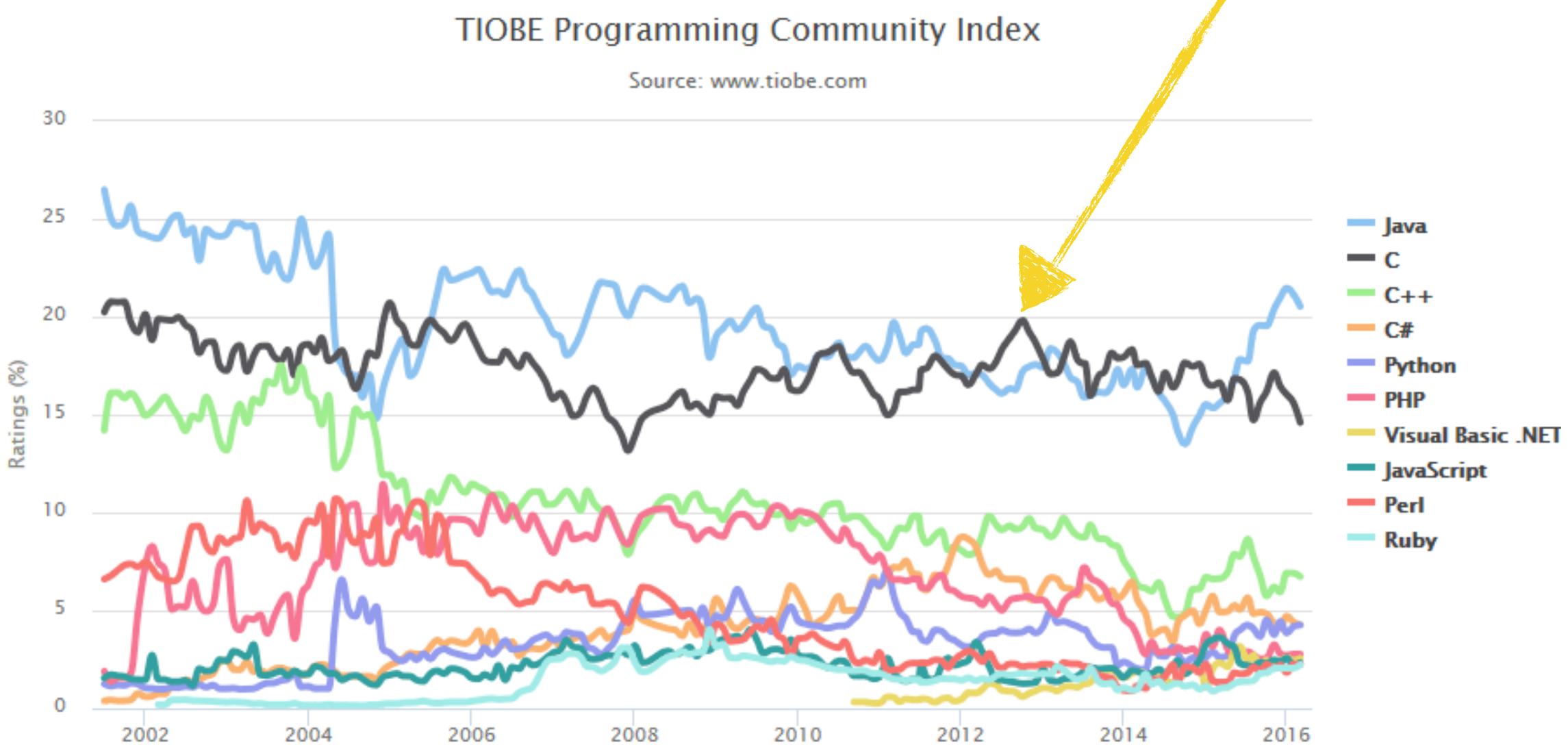
* was not the a primary design goal in advanced but turned out to be reasonable

C Programming Language

- General-purpose programming language
  - structured: built-in support of sub-routines („functions“), loops, and block structures
  - imperative: computation is expressed as statements changing program state
  - procedural: problem solving step by step by a particular order on procedure calls
  - static variable scope: names refers to its local lexical environment
  - supports recursion: problem solution depends on solutions to smaller instances of same problem
  - static type system: types of variables are known at compile time (weak enforced)
- High-level programming language which is often perceived as „low-level“
  - characters, numbers and addresses are first-class citizen
    - composite objects aren’t
  - sometimes referred as „portable assembler“
- often perceived as system programming language (database, operating systems)
- development driven by first UNIX operating system implementation to achieve portability
  - only a minor part of the kernel is written in (platform-dependent) Assembler; rest in C
- It’s around for 40 years, and stable in its popularity

The Market of Programming Languages

according to the TIOBE index, C is both popular and stable in its popularity



Notable Properties

- C implementations must provide functions to enable „standard“ functions that are *not* built-into the C language itself (due to goal of small and portable language):
  - operation to composite objects (strings, lists, arrays)
  - storage definition beyond the built-in static one (e.g., heap or garbage collection)
  - input/output functionalities, file access methods
- Most other language compilers are required to provide call-into/out-call to C
- Deterministic destruction of objects
- Explicit dynamic memory allocation and deallocation
- C comes with a preprocessor that is not part of the C language itself
  - file inclusion
  - macro substitution
  - conditional compilation
- Since C11, multi-threaded control flow is part of the language per design

Programming in C

PROs

- C is small, and clean: limited number of keywords, and compact language concepts support understanding of third-party code.
- Modular code: separate compiling and linking of source files including basic forms for information hiding
- Slow evolution of an old language: new standards does not radically rewrite C and, hence, do not break existing code
- Time and memory efficient programs: programs in C are compiled to native code, fast, and have little memory overhead.
- C code is portable: as long as one considers the C language specification and puts some effort in cross-platform design, unmodified C code can be compiled to all major platforms*

CONs

- Strings are a missing concept: there is no explicitly concept of string. Instead, strings are implicitly available by the concepts of null terminated sequences of characters.
- Security flaws: although minimal in its design, the correct use of C is hard; origin of attack surfaces
- Missing composite object library: C is *not* shipped with most important data structures (lists, maps, …) on board. Sometimes „Reinventing the wheel“
- No built-in boolean values: „true“ and „false“ are defined constants but not a language concept. Sometimes confusing or problems during runtime.
- Potential memory leaks: Due to manual explicit management of dynamic memory, memory leaks can occur when incorrectly implemented

- Almost no limitation on what one can do: C has no built-in mechanism preventing you from doing things (cf. Java references vs. C pointers). But this power comes with great responsibility.

* The code is portable while the binary is not. However, compiler-specific differences in the implementation of the C specification, operating-system-specific interpretation of the POSIX standard, vendor-specific extension, platform-depending libraries etc. limit out-of-the-box portability of C programs.

History of C

1978 — K&R-C
First implementation by Brian W. Kernighan und Dennis Ritchie, and promoted in the famous book „The C Programming Language (1st Edition)“

1987 — X/Open-C
First attempt to standardize the language

1989 1990 — ANSI C aka C89 aka ISO C90
First standardized version of C (by ANSI, later by ISO).

New language features: function prototypes, possibility to declare constant values, more powerful preprocessor, `void` for empty function parameter list and as function return type for function who return nothing, new keywords `const`, `volatile` and `signed`, added support for characters with more than 8bit width

First specification of the C standard library.

1995 — ISO C95
Error corrections and some new features: alternate operator spelling, and standard macro `__STDC_VERSION__`

History of C

1999

ISO C99

New features: `inline` functions, variable declaration inside `for` statement, complex number via `_Complex` type, new type `long long` with 64 bit size at least, variable length arrays (VLA), boolean type `_Bool`, more math function in standard library, new keyword `restrict`, declaration anywhere inside blocks, restriction to use implicit function declaration and force function return type, variable length preprocessor macros, line comment `//` added,

2011

ISO C11

Native support of multi-threading (cf. standard library `<threads.h>`, `<stdatomic.h>`), control over data alignment & structure padding & packing, Unicode support (new types `char16_t`, `char32_t` and `<uchar.h>` in standard library), security improvements on the standard library, added exclusive read/write mode for file I/O, generic datatypes via `_Generic`

Quotes from Bjarne Stroustrup

Bjarne Stroustrup,
Creator of C++

C is flexible. It is possible to apply C to most every application area and to use most every programming technique with C. The language has no inherent limitations that preclude particular kinds of programs from being written

C is efficient. The semantics of C are „low level“; that is, the fundamental concepts of C mirror the fundamental concepts of a traditional computer. Consequently, it is relatively easy for a compiler and/or programmer to efficiently utilize hardware resources for C programs

Quotes from Bjarne Stroustrup

Bjarne Stroustrup,
Creator of C++

C is available: Given a computer, whether the tiniest micro or the largest super-computer, chances are that there is an acceptable quality C compiler available and that that C compiler supports an acceptably complete and standard C language and library. Libraries and support tools are also available, so that a programmer rarely needs to design a new system from scratch

C is portable: A C program is not automatically portable from one machine (and operating system) to another, nor is such a port necessarily easy to do. It is however, usually possible and the level of difficulty is such that porting even major pieces of software with inherent machine dependences is typically technically and economically feasible

Tipp

Super useful resource

http://en.cppreference.com/w/c