Introduction to Computer and Programming

Chapter 5: Introduction to C

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Outline

The birth of C

In the old time:

- Unix OS was implemented in assembly
- New hardware implied new possibilities
- New possibilities implied new code
- Much time wasted rewriting the OS for the new hardware

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Development of a new language:

- Authors: Ken Thompson & Dennis Ritchie
- Location: AT&T Bell Labs
- Time frame: 1969 – 1973
- Name: C, as derived from B

Why using C?

Main characteristics:

- One of the most widely used languages
- Available for the majority of computer architectures and OS
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Advantages of C:

- Performance
- Interface directly with hardware
- Higher level than assembly
- Low level enough
- Zero overhead principle

Development environment

Common software to write C code:

- Text editor + compiler
- Code::Blocks, Geany, Xcode, Clion, Visual studio code
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- Clang
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- Microsoft visual C++ $\leftarrow$ **BAD!**

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A first example

gm-base.c

```c
#include <stdio.h>
int main () {
  printf("good morning!\n");
  return 0;
}
```

Program structure:

- A unique `main` function: used only to "dispatch" the work
- Other functions: effectively doing the work

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Writing a C function:

```
OType FName(IType IName,...) {
  function's body
}
```

Compilation: `gcc gm-base.c -o gm-base`

Blocks

Explain the following code:

blocks.c

```c
#include <stdlib.h>
#include <stdio.h>
int main () {
  {
    int a=0; printf("%d ",a);
  }
  {
    double a=1.124; printf("%f ",a);
  }
  {
    char a='a'; printf("%c ",a);
  }
//  printf("%d",a);
}
```

Shorthand operators

Questions.

- How is the code indented?
- Why is line 13 commented out?
- What happens if lines 9 and 10 are deleted?

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Common shortcuts:

- Increment: e.g. `a++`
- Decrement: e.g. `a--`
- Add: e.g. `x+=y`
- Subtract: e.g. `x-=y`
- Multiply: e.g. `x*=y`
- Divide: e.g. `x/=y`

The `#include` instruction

Roles of a header file:

- Define function prototypes
- Define constants, data types...
- A function used in a program must have been defined earlier

Syntax to include `header.h`:

- Known system-wide: `#include<header.h>`
- Unknown to the system: `#include "/path/to/hearder.h"`

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Result of `#include<stdio.h>`: `gcc -E gm-base.c`

The `#define` instruction

Goal:

- Set “type-less” read-only variables
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gm-def.c

```
1 #include <stdio.h>
2 #define COURSE "VG101"
3 int main () {
4   printf("good morning %s!\n",COURSE);
5 }
```

Result of `#define`: `gcc -E gm-def.c`

Taking advantage of #define

The #ifdef and #ifndef instructions:

- Test if some "#define variable" is (un)set
- Compile different versions of a same program

gm-ifdef.c

```c
#include <stdio.h>
#define POLITE
int main () {
#ifdef POLITE
  printf("good morning!\n");
#endif
}
```

gm-ifndef.c

```c
#include <stdio.h>
int main () {
#ifndef RUDE
  printf("good morning!\n");
#endif
}
```

Result of #if(n)def: `gcc -E gm-if(n)def.c`

More on #define

Writing simple macros:

- Define type-less functions
- Perform fast and simple actions
- To be used only on specific circumstances (e.g. min/max)
- Do not use for regular functions

gm-macro.c

```c
#include <stdio.h>
#define SPEAK(x) printf("good morning %s!\n",x)
int main () {
  SPEAK("VG101");
  SPEAK("VE475");
}
```

Result of macros: `gcc -E gm-macro.c`

Common compilation errors

Often the compilation process fails because of:

- Syntax errors
- Incompatible function declarations
- Wrong Input and Output types
- Operations unavailable for a specific data types
- Missing function declarations
- Missing machine codes for some functions

Outline

More complex programs

The main function:

- Never write a whole program in the main function
- Use the main function to dispatch the work to other functions
- Most of the coding must be done outside of the main function

Reminders:

- Always add comments to the code
  - A single line: start with `//`
  - Multiple lines: anything between `/*` and `*/`
- As much as possible use a function per task or group of tasks
- If the program becomes large split it over several files

A long program

ans-orig.c

```c
#include <stdio.h>
double answer(double d);
int main () {
  double a;
  scanf("%lf",&a);
  printf("%lf\n", answer(a));
}
double answer(double d) {return d+1337;}
```

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```

Functions and operators used:

- Display the integer contained in *a*: `printf("%d",a)`
- Read and store an integer in *a*: `scanf("%d",&a)`
- Both functions can take a variable number of parameters
- Arithmetic operators: `+`, `-`, `/`, `%`

Organising a long program

Splitting the code over several files:

ans-main.c

```c
#include <stdio.h>
#include "ans.h"
int main () {
  double a; scanf("%lf",&a); printf("%lf\n", answer(a));
}
```

ans.c

```c
#include "ans.h"
double answer(double d) {
  return d+1337;
}
```

ans.h

```c
#ifndef ANS_H
#define ANS_H
double answer(double d);
#endif
```

Compilation: `gcc ans-main.c ans.c -o ans`

Libraries

Library: collection of functions, macros, data types and constants

Example.
The C mathematics library:

- Mathematical functions (log, exp, trigonometric, floor...)
- Add header: `#include <math.h>`
- Add the corresponding compiler flag: `gcc -lm`

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math.c

```c
#include<stdio.h>
#include<math.h>
int main() {
  printf("%g\n",gamma(sqrt(cosh(M_PI/2))));
}
```

Key points

- Why is C one of the most widely used programming language?
- Is C a compiled or interpreted language?
- How to transform a C program into machine code?
- Why are data types of a major importance?

Thank you!