Introduction to Systems Programming

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General Information

- http://www.inf.usi.ch/carzaniga/edu/sysprog/
- INFO.B298 on https://www2.icorsi.ch/course/view.php?id=4908

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- Announcements
 - http://www.inf.usi.ch/carzaniga/edu/sysprog/news.html
 - or through iCorsi
 - you are responsible for reading the announcements page (or reading the announcements sent through iCorsi)

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 - you are responsible for reading the announcements page (or reading the announcements sent through iCorsi)
- Office hours
 - Antonio Carzaniga: by appointment
 - Daniele Rogora: by appointment

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 - without forgetting good software engineering practices

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- Focus: *concrete and practical* systems programming
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- Structure: lecture + in-class exercises + weekly assignments
- Lectures
 - interactive lectures
 - in-class exercises
 - so, you should have your computer handy
- Homework assignments
 - a programming assignment every week
 - some assignments will be graded (we'll tell you which ones)
 - some will not be graded
 - all assignments will be discussed in class

Evaluation

- +40% programming assignments
 - grades added together, thus resulting in a weighted average
- +30% midterm exam
 - in-class programming using your computer
- +30% final exam
 - in-class programming using your computer
- ±10% instructor's discretionary evaluation
 - participation
 - extra credits
 - trajectory
 - **-** . . .

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- −100% plagiarism penalties



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- You know what I mean...
- Committing plagiarism on an assignment or an exam will result in
 - failing that assignment or that exam
 - loosing one or more points in the final note!
- Penalties may be escalated...



Deadlines

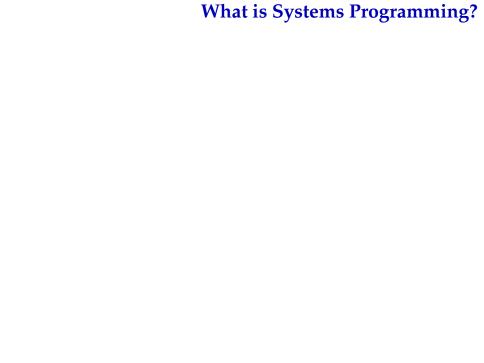
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- You know what I mean...
- Usual three-days-and-you're-out rule applies here...

Now on to *Systems Programming!*

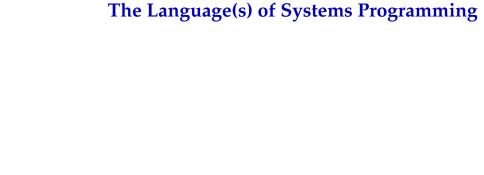


What is Systems Programming?

- Interfacing with a "system" (as opposed to a user)
 - rigid interfaces
 - complex interfaces

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 - rigid interfaces
 - complex interfaces
- Engineering for a non trivial platform
 - non-trivial performance profiles
 - going beyond algorithmic complexity



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- System programming
 - "low-level" programming (e.g., a device driver)
 - "high-level" programming (e.g., the Mozilla web browser)
- Relatively simple but powerful language
 - C++ is definitely not that simple
 - ▶ like any serious tool, C and C++ have hidden complexities...



Getting Started

1. Edit the program *ciao.c*

```
#include <stdio.h>
int main () {
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   return 0;
}
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% cc ciao.cc -o ciao
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```

3. Step 3: run the program

```
% ./ciao
```



Getting Started in C++

1. Edit the program ciao2.cc

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#include <iostream>
int main () {
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```
% c++ ciao2.cc -o ciao2
```

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int main () {
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}</pre>
```

2. Compile the program (i.e., run the compiler)

```
% c++ ciao2.cc -o ciao2
```

3. Run the program

```
% ./ciao2
```



Getting Started with Make

1. Edit the program ciao3.cc

```
#include <iostream>
int main() {
    std::cout << "I said Ciao already!\n";
}</pre>
```

Getting Started with Make

1. Edit the program *ciao3.cc*

```
#include <iostream>
int main() {
    std::cout << "I said Ciao already!\n";
}</pre>
```

2. Compile the program using make

```
% make ciao3
```

Getting Started with Make

1. Edit the program ciao3.cc

```
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int main() {
   std::cout << "I said Ciao already!\n";
}</pre>
```

2. Compile the program using make

```
% make ciao3
```

3. Run the program

```
% ./ciao3
```



Errors

Try compiling the program:

```
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int main() {
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```

You should get some errors:

```
% g++ errors.cc -o errors
errors.cc: In function 'int main()':
errors.cc:4:5: error: 'cout' was not declared in this scope
...
```

Printing

The function you will use to print data in C is printf:

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The first argument is a **format string** that includes **conversion specifications**, begining with a % sign, that tell printf how to interpret its other arguments:

```
%d prints an integer in decimal notation
%c prints an integet as a character
%g prints a float in decimal notation
... see the documentation of printf()
```

Printing in C++

Printing is quite different (simpler?) in C++:

Digression: How does this really work?

Basic Types

C has pretty much the set of basic types you would expect

```
#include <stdio.h>
int main() {
   int i;
   char c:
   float x;
   i = 10;
   c = 'a':
   x = 1.2;
   printf("i=%d, c=%c, x=%f\n", i, c, x);
```

Integer Types

Typically two's complement; ranges defined in inits.h>

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type	min value	max value	size in bits	typical
char	CHAR_MIN	SCHAR_MAX		
signed char	SCHAR_MIN	SCHAR_MAX	CHAR_BIT	8
unsigned char	0	UCHAR_MAX		
short	SHRT_MIN	SHRT_MAX	≥CHAR_BIT	16
unsigned short	0	USHRT_MAX		
int	INT_MIN	INT_MAX	>short	32
unsigned int	0	UINT_MAX	≥311011	32
long	LONG_MIN	LONG_MAX	≥int	64
unsigned long	0	ULONG_MAX		
long long	LLONG_MIN	LLONG_MAX	≥long	64
unsigned long long	0	ULLONG_MAX	210116	04

Bit Sizes

Test your platform with this C program:

```
#include <stdio.h>

int main() {
    printf("char: %zu\n", sizeof(char));
    printf("short: %zu\n", sizeof(short));
    printf("int: %zu\n", sizeof(int));
    printf("long: %zu\n", sizeof(long));
    printf("long long: %zu\n", sizeof(long long));

    return 0;
}
```

Limits

Test your platform with this C++ program:

```
#include <liimits>
#include <iostream>
int main() {
   std::cout
       << "short: " std::numeric_limits<short>::min()
       << ' ' << std::numeric_limits<short>::max() << '\n'
       << "int: " << std::numeric_limits<int>::min()
       << ' ' << std::numeric_limits<int>::max() << '\n'
       << "long: " << std::numeric_limits<long>::min()
       << ' ' << std::numeric_limits<long>::max() << '\n'
       << "long long: "
       << std::numeric_limits<long long>::min() << ' '
       << std::numeric_limits<long long>::max() << '\n';</pre>
```

Literal Values

C and C++ have the usual literal values:

```
int i = -1;
char c = 'A';
float f = 0.2;
double pi = 3.14159265358979323846;
unsigned long N = 0xffffffff;
unsigned long M = 1UL;
int diff = '9' - '4';
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- **Warning:** char values aren't really *characters*
 - ► Characters are things like \aleph , ψ , \spadesuit , $\tilde{\mathsf{n}}$, a, A, <, $\dot{\mathsf{E}}$, ...

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- Warning: char values aren't really characters
 - ► Characters are things like \aleph , ψ , \spadesuit , $\tilde{\mathsf{n}}$, a, A, <, $\dot{\mathsf{E}}$, . . .
 - Basic characters: latin alphabet: A...Z a...z, decimal digits: 0...9, graphic characters: !; "<#=%>&?'[]()...
 - Digression: how would you represent characters on a computer?



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 - returns an int value
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Example:



putchar(int c) writes one byte to the "standard output"

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Example:

```
#include <stdio.h>
#include <limits.h>

int main() {
   int c;
   while((c = getchar()) != EOF) {
      c += 3;
      if (c > CHAR_MAX)
            c = CHAR_MIN + (c - CHAR_MAX);
      putchar(c);
   }
}
```

Control Structures

■ C has the usual control structures: for, while, do...while, switch, if...else..., break, continue, return

```
int f(int n) {
   int p, pp, r;
   switch(n) {
   case 0:
   case 1: return n;
   default:
       p = 1;
       pp = 0;
       do {
           r = p + pp;
           pp = p;
           p = r;
       } while (--n > 1);
       return r;
```

Control Structures: Exercise 1

■ Rewrite without using the switch statement

```
int main () {
   int c;
   while ((c = getchar()) != EOF) {
       switch (c) {
       case ' ': putchar('\n'); break;
       case '\n': putchar('\n'); putchar('\n'); break;
       case 'a':
       case 'e':
       case 'i':
       case 'o':
       case 'u':
           putchar(c);
           putchar('s');
       default:
           putchar(c);
```

Control Structures: Exercise 2

■ Write a program that *reverts* this input/output transformation:

```
int main () {
   int c;
   while ((c = getchar()) != EOF) {
       switch (c) {
       case ' ': putchar('\n'); break;
       case '\n': putchar('\n'); putchar('\n'); break;
       case 'a':
       case 'e':
       case 'i':
       case 'o':
       case 'u':
           putchar(c);
           putchar('s');
       default:
           putchar(c);
```

Homework Assignment: wordcount

■ Write a program called *wordcount* that counts the words in the standard input.

A *word* is a sequence of one or more characters delimited by white space.

the output should be the same as the command:

% wc -w