

TWO LANGUAGES FOR THE PRICE OF ONE

- Before being passed to the compiler proper, your program passes through a **preprocessor**.
 - Your program is passed first to the preprocessor, and the result is further passed to the C++ compiler.
- The preprocessor has a language of its own.
 - This language is **not** part of C++.
 - In particular, it has a different syntax, and requires a different mindset to use.
 - Most problems occur when the preprocessor is treated like C++.
 - The preprocessor language is tailored to the task of translating code.
- In a C++ program, you should not abuse the preprocessor.
 - Use it when needed.
 - Use it to increase efficiency, but only if you can think of no alternative (and keep in mind that such increased efficiency is often not justified).

INCLUDE DIRECTIVES

- The functionality of the preprocessor is based on **directives**.
- A preprocessor directive starts with a **#** character and **extends to the end of line**.
 - There is **no** terminating semicolon.
- A useful directive:

```
#include <iostream>
#include "lists.h"
```

- The effect of `#include "foo.h"` is the replacement of the directive with the **content of the file "foo.h"**.
 - Filenames can be passed to `#include` using an absolute (e.g., `/usr/include/stdio.h`) or relative (e.g., `sys/stat.h`) path.
 - * Under Windows, you should use the backslash (`\`) instead of slash (`/`).
 - * As opposed to C++ proper, **do not use `\\`**!
 - Relative to what?

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 - Relative to what?
 - * To predefined directories with known headers, and to the current directory (`.`).

INCLUDE DIRECTIVES (CONT'D)

- There are two variants of an include directive.

```
#include <iostream>
#include "lists.h"
```

- The difference is the **order** in which the directories are searched for the respective file.
 - The angle bracketed version causes the preprocessor to look into the predefined directories first.
 - The double quoted variant tells the preprocessor to look first in the current directory.
 - The latter is normally used to include the headers written by you.
 - Proper use of these variants is a matter of self-documentation of the code, and is thus encouraged.
- The `#include` directive is intended for inclusion of header files. Using it like this:

```
#include "btree.cc"
```

is certainly possible, but is **very bad** programming practice. ([why?](#))

CONDITIONAL COMPILATION

- **Problem.** We want to build a program that compiles under Windows as well as Unix. What do we do with the `#include` directives?
- **Solution.** We use **conditional compilation**:

```
#ifndef __MSDOS__
#include <sys/stat.h>
#else /* __MSDOS__ */
#include <sys\stat.h>
#endif /* __MSDOS__ */

#ifdef __MSDOS__
const char* filename = "\\home\\bruda\\foo";
#else /* __MSDOS__ */
const char* filename = "/home/bruda/foo";
#endif /* __MSDOS__ */
```

- The portion of the file between `#ifdef C` and `#endif` is passed to the compiler if and only if the “macro” `C` is defined using `#define`.
 - Some macros are defined for you, and you can define more using `#define` in your program or the `-D` switch of `g++`.

CONDITIONAL COMPILATION (CONT'D)

- Another example of conditional compilation: **debug code**

```
#ifdef DEBUG
cout << "### added " << lst -> car << " to " << lst << "\n";
#endif /* DEBUG */
```

- Whenever you want to debug your program, you can define `DEBUG` as follows:
 - In the code of the module you need to debug, by putting the following directive at the beginning of the C++ file

```
#define DEBUG
```

- If your module is called `foo`, you can define `DEBUG` for it at compile time:

```
g++ -g -Wall -DDEBUG -o foo.o foo.cc
```

- You can also “undefine” a macro:

```
#undef DEBUG
```

MORE DEFINE DIRECTIVES

- We defined up to this point macros without values.
 - I.e., they either exist or not.
 - Useful for conditional compilation.
- We can also associate **values** with our macros.

```
#define SIZE 128
```

In general, we write: `#define Name Substitute-text`

- The effect: the **string** *Name* is **literally and globally replaced** with the **string** *Substitute-text* throughout the code before the code is passed to the C++ compiler.

MACROS VERSUS CONST VARIABLES

- Compare:

```
#define SIZE 128  
const int SIZE = 128;
```

- `const` variables are preferred over macros.

- A variable declaration uses familiar syntax.
- The syntax of a variable declaration is checked immediately.
 - * The syntax of a `#define` directive is checked when it is first used.
 - * The error line reported by the compiler is not the line where the error actually happens!
- A variable declaration follows scoping rules; a `#define` directive is always global.
- It might be the case that a macro produces more efficient code, but the efficiency gain is negligible for most normal programs.

- Sometimes, however you are better off if you use macros.

- How would you define the constant `NULL`?

UNEXPECTED RESULTS

```
1. // Real error on line 2:
2. #define BIG_NUMBER 10 ** 10
3.
4. int main () {
5.     int i = 0;
6.     while ( i < BIG_NUMBER ) // Error signalled on line 6!
7.         i *= 10;
8. }
```

```
1. #define A_NUM 7
2. #define ANOTHER_NUM 6
3. #define A_SUM A_NUM + ANOTHER_NUM
4.
5. cout << "Squared sum: " << A_SUM * A_SUM << "\n";
```

```
1. #define MAX =10
2.
3. for (counter=MAX; counter > 0; counter --) // error and warning here!
4.     cout << "Hello\n";
```

THINGS YOU CAN BUT SHOULD NOT DO WITH MACROS

- Obscure the basic control flow of a program:

```
#define FOR_ALL for (int i = 0; i < ARRAY_SIZE; i++)  
  
FOR_ALL {  
    data[i] = 0;  
}
```

- Obfuscate your code, e.g., by using a half-C++, half-Pascal language:

```
#define begin {  
#define end }  
  
if (index == 0)  
begin  
    data[i] = -1;  
end
```

PARAMETERIZED MACROS

- Macros can also take parameters:

```
#define SQR(x) ((x) * (x))
#define MAX(x,y) ( (x) < (y) ? (y) : (x) )
#define RECIP (x) ( 1.0 / (x) )

for (int i = 0; i < 10; i++)
    cout << SQR(i);
cout << MAX(1,2) << " " << RECIP(1); // undefined variable x!
```

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#define RECIP(x) ( 1.0 / (x) )
```

```
for (int i = 0; i < 10; i++)  
    cout << SQR(i);  
cout << MAX(1,2) << " " << RECIP(1);
```

- Never put inside parameterized, arithmetic macros operations with side effects (such as ++).
 - In other words, differentiate between macros that do arithmetic and macros that contain statements, and never mix them.
- Do not separate the list of parameters from the name of the macro.

RULES TO MINIMIZE TROUBLES

- Macros are sometimes unavoidable and/or make your life easier. But they tend to create trouble if you abuse them and/or you make mistakes when defining them.
- When working with macros, KISS (keep it simple, stupid).
 - define empty macro as you need them
 - define parameterless macros if you cannot think of anything else
 - think twice before declaring macros with parameters.
- Put brackets around everything in an arithmetic macro.
- When defining a macro with more than one C++ statement, surround it by braces.
- The preprocessor is **not** C++. Do **not** use C++ syntax.