Part VI

The C Preprocessor

C and its Preprocessor | Hello World | Features | File Inclusion | Macro Substitution

Conditional Inclusion | Errors and Warnings | Phases

C and its Preprocessor

A preprocessor is a program that takes input data (e.g., source files), processes (aka preprocesses) it, and moves its output to another program (e.g., a compiler).

Preprocessors Types

- lexical: replace character tokens by other tokens driven by user-defined rules
  - file inclusion
  - conditional inclusion
  - macro definition and substitution
- syntactic: transformation of syntax trees driven by user-defined rules
  - sometimes turing-complete computations
  - language extension

Hello World in C-Preprocessor

The C preprocessor is lexical preprocessor mostly used for the C/C++ language

Most simple beginners program outputting „Hello World“

C-Preprocessor directives start with #

material/Chapter 02/00 Hello World/hello_world_preproc.c

```
#warning Hello World
```

- Run pre-processor only on that file (typically -E argument)

```
$ cc -E hello_world_preproc.c
# 1 "hello_world_preproc.c"
# 1 "<built-in>" 1
# 1 "<built-in>" 3
# 329 "<built-in>" 3
# 1 "<command line>" 1
# 1 "<built-in>" 2
# 1 "hello_world_preproc.c" 2
hello_world_preproc.c:1:2: warning: Hello World [-W#warnings]
#warning Hello World
 ^

1 warning generated.
```

C Preprocessor Features

- FILE INCLUSION
- MACRO SUBSTITUTION
- CONDITIONAL INCLUSION
- STATE MESSAGES
- COMPILER DIRECTIVES

File Inclusion

TOKEN REPLACEMENT DIRECTIVE

```
#include "filename"
```

resp.

```
#include <filename>
```

Macro Substitution (1)

Defined a macro:

```
#define identifier replacement
```

optional

Defined a macro (function style):

```
#define identifier ( identifier,…, identifier ) replacement
```

optional

optional

Check macro definition exists:

```
defined ( identifier )
```

braces are optional

optional

expands to 1 iff identifier is defined

Undefine a macro

```
#undef identifier
```

Macro Substitution (2)

Standard Pre-Defined Macros

- `__FILE__` expands to current input file name, e.g., `/home/marcus/arcade/main.c`
- `__LINE__` expands to current input line number, e.g., `23`
- `__DATE__` expands to date the preprocessor run, e.g., `Nov 06 2017`
- `__TIME__` expands to time the preprocessor run, e.g., `21:49:32`
- `__STDC__` expands to `1` if compiler is ISO C conform
- `__STD_VERSION__` expands to C Standard version number
- `__STD_HOSTED__` expands to `1` if environment supports complete standard library
- `__cplusplus` is defined iff a C++ compiler is used
- `__OBJC__` is defined and expands to `1` iff a Objective-C compiler is used
- `__ASSEMBLER__` is defined and expands to `1` iff Assembler language is preprocessed
- `__func__` expands to the current function name

Macro Substitution (3)

Common Pre-Defined Macros

Common pre-defined macros are implementation-defined

- macros to get version information of compiler
- checking whether strict ISO conformance is enforced
- macros to get various flags regarding enabled compiler optimization
- macros to get correct size in byte of various types
- macros to get the byte-order (little endian, big endian)
- ...

Macro Substitution (4)

User-specific Macros

Macros defined as argument to the preprocessor itself

- given as argument, e.g., `-D` flag in cc compiler
- existence and value check as for other macros
- user-defined semantic , e.g.,
  - platform-specific definition of symbols to check operating system
    - example `cc -DPLATFORM_UNIX -DPLATFORM_NAME=macOS`
  - fine-grained turning on or off of options
    - example `cc -DLOGGING=off -DBACKUP=on`

Conditional Inclusion

```
#if expression
```

Errors and Warnings

STATE MESSAGES

stop preprocessing and output `message` as error

```
#error message
```

stop preprocessing and output `message` as warning

```
#warning message
```

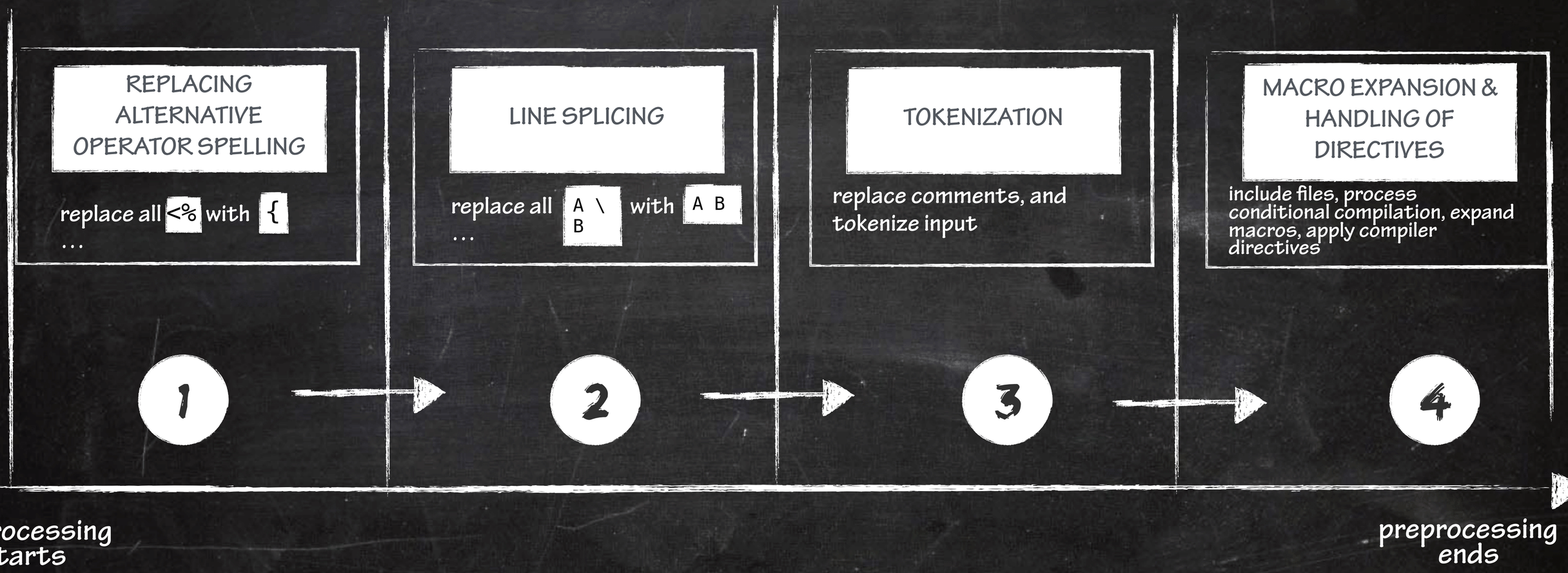
Errors and Warnings

COMPILER DIRECTIVES

```
#pragma  text
```

C and its Preprocessor

Phases



C and its Preprocess

Phase

0

material/Chapter 02/00 Hello World/cpp_phases.c

```
#include <stdio.h>

#define ENABLE_PRINTER
#define SOME_FLAG true

#ifdef  ENABLE_PRINTER
    #define PRINT(text)       \
        printf("Printer: "); \
        printf(text)
#else
    #define PRINT()
#endif

#ifdef  COMPILER_PACK_STRUCT
    #pragma pack(push, 1)
#endif

struct structure
<%
    char a;
    int b;
    short c;
%>;

#ifdef COMPILER_PACK_STRUCT
    #pragma pack(pop)
#endif

main() {
    PRINT("Hello World\n");
    printf("size: %dByte\n",
           sizeof(struct structure));
}
```

file inclusion directive

symbol definition

constant definition

conditional removing or addition of text blocks

macro definition

substitution

C and its Preprocess

Phase

REPLACING
ALTERNATIVE
OPERATOR SPELLING

replace all <% with {
...

1

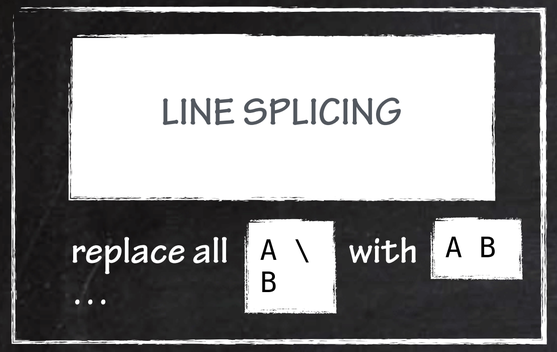
material/Chapter 02/00 Hello World/cpp_phases.c

```c
#include <stdio.h>

#define ENABLE_PRINTER
#define SOME_FLAG

#ifdef  ENABLE_PRINTER
    #define PRINT(text)       \
        printf("Printer: "); \
        printf(text)
#else
    #define PRINT()
#endif

#ifdef  COMPILER_PACK_STRUCT
    #pragma pack(push, 1)
#endif

struct structure
<%
    char a;
    int b;
    short c;
%>;

#ifdef COMPILER_PACK_STRUCT
    #pragma pack(pop)
#endif

main() {
    PRINT("Hello World\n");
    printf("size: %dByte\n",
            sizeof(struct structure));
}
```

```c
#include <stdio.h>

#define ENABLE_PRINTER
#define SOME_FLAG

#ifdef  ENABLE_PRINTER
    #define PRINT(text)       \
        printf("Printer: "); \
        printf(text)
#else
    #define PRINT()
#endif

#ifdef  COMPILER_PACK_STRUCT
    #pragma pack(push, 1)
#endif

struct structure
{
    char a;
    int b;
    short c;
};

#ifdef COMPILER_PACK_STRUCT
    #pragma pack(pop)
#endif

main() {
    PRINT("Hello World\n");
    printf("size: %dByte\n",
            sizeof(struct structure));
}
```

C and its Preprocess

Phase



2

material/Chapter 02/00 Hello World/cpp_phases.c

```c
#include <stdio.h>

#define ENABLE_PRINTER
#define SOME_FLAG

#ifdef  ENABLE_PRINTER
    #define PRINT(text)     \
        printf("Printer: "); \
        printf(text)
#else
    #define PRINT()
#endif

#ifdef  COMPILER_PACK_STRUCT
    #pragma pack(push, 1)
#endif

struct structure
{
    char a;
    int b;
    short c;
};

#ifdef COMPILER_PACK_STRUCT
    #pragma pack(pop)
#endif

main() {
    PRINT("Hello World\n");
    printf("size: %dByte\n",
            sizeof(struct structu
}
```

```c
#include <stdio.h>

#define ENABLE_PRINTER
#define SOME_FLAG

#ifdef  ENABLE_PRINTER
    #define PRINT(text) printf("Printer: ");prin
#else
    #define PRINT()
#endif

#ifdef  COMPILER_PACK_STRUCT
    #pragma pack(push, 1)
#endif

struct structure
{
    char a;
    int b;
    short c;
};

#ifdef COMPILER_PACK_STRUCT
    #pragma pack(pop)
#endif

main() {
    PRINT("Hello World\n");
    printf("size: %dByte\n",
            sizeof(struct structure));
}
```

C and its Preprocess

material/Chapter 02/00 Hello World/cpp_phases.c

Phase

TOKENIZATION

replace comments, and tokenize input

3

```
#include <stdio.h>

#define ENABLE_PRINTER
#define SOME_FLAG

#ifdef ENABLE_PRINTER
    #define PRINT(text) printf…
#else
    #define PRINT()
#endif

#ifdef COMPILER_PACK_STRUCT
    #pragma pack(push, 1)
#endif

struct structure
{
    char a;
    int b;
    short c;
};

#ifdef COMPILER_PACK_STRUCT
    #pragma pack(pop)
#endif

main() {
    PRINT("Hello World\n");
    printf("size: %dByte\n",
           sizeof(struct structu
}
```

```
#include <stdio.h>

#define ENABLE_PRINTER
#define SOME_FLAG

#ifdef ENABLE_PRINTER
    #define PRINT(text) printf…
#else
    #define PRINT()
#endif

#ifdef COMPILER_PACK_STRUCT
    #pragma pack(push, 1)
#endif

struct structure
{
    char a;
    int b;
    short c;
};

#ifdef COMPILER_PACK_STRUCT
    #pragma pack(pop)
#endif

main() {
    PRINT("Hello World\n");
    printf("size: %dByte\n",
           sizeof(struct structu
}
```

preprocessor tokens

don't know tokens

C and its Preprocess

material/Chapter 02/00 Hello World/cpp_phases.c

Phase

MACRO EXPANSION & HANDLING OF DIRECTIVES

include files, process conditional compilation, expand macros, apply compiler directives

4

```
#include <stdio.h>

#define ENABLE_PRINTER
#define SOME_FLAG

#ifdef ENABLE_PRINTER
    #define PRINT(text) printf(text)
#else
    #define PRINT(text)
#endif

#ifdef COMPILER_PACK_STRUCT
    #pragma pack(push, 1)
#endif

struct structure
{
    char a;
    int b;
    short c;
};

#ifdef COMPILER_PACK_STRUCT
    #pragma pack(pop)
#endif

main() {
    PRINT("Hello World\n");
    printf("size: %dByte\n",
           sizeof(struct structu
}
```

(file content of stdio.h)

```
#define ENABLE_PRINTER
#define SOME_FLAG

#ifdef ENABLE_PRINTER
    #define PRINT(text) printf(text)
#else
    #define PRINT(text)
#endif

#ifdef COMPILER_PACK_STRUCT
    #pragma pack(push, 1)
#endif

struct structure
{
    char a;
    int b;
    short c;
};

#ifdef COMPILER_PACK_STRUCT
    #pragma pack(pop)
#endif
```

preprocessor tokens

don't know tokens

material/Chapter 02/00 Hello World/cpp_phases.c

C and its Preprocess

Phase

MACRO EXPANSION & HANDLING OF DIRECTIVES

include files, process conditional compilation, expand macros, apply compiler directives

4

known symbol

unknown symbol

(file content of stdio.h)

```
#define ENABLE_PRINTER
#define SOME_FLAG ?

#ifdef  ENABLE_PRINTER
    #define PRINT(text) printf…
#else
    #define PRINT()
#endif

#ifdef  COMPILER_PACK_STRUCT ?
    #pragma pack(push, 1)
#endif

struct structure
{
    char a;
    int b;
    short c;
};

#ifdef COMPILER_PACK_STRUCT ?
    #pragma pack(pop)
#endif
```

(file content of stdio.h)

```
#define PRINT(text) printf…

struct structure
{
    char a;
    int b;
    short c;
};

main() {
    PRINT("Hello World\n");
    printf("size: %dByte\n",
            sizeof(struct structure))
}
```

C and its Preprocess

material/Chapter 02/00 Hello World/cpp_phases.c

Phase

MACRO EXPANSION & HANDLING OF DIRECTIVES

include files, process conditional compilation, expand macros, apply compiler directives

4

```
(file content of stdio.h)

#define PRINT(text) printf("Printer: …

struct structure
{
    char a;
    int b;
    short c;
};

main() {
    PRINT("Hello World\n");
    printf("size: %dByte\n",
            sizeof(struct structure))
}
```

```
(file content of stdio.h)

struct structure
{
    char a;
    int b;
    short c;
};

main() {
    printf("Printer: ");printf("Hello W
    printf("size: %dByte\n",
            sizeof(struct structure))
}
```