Macro and Bit Operations

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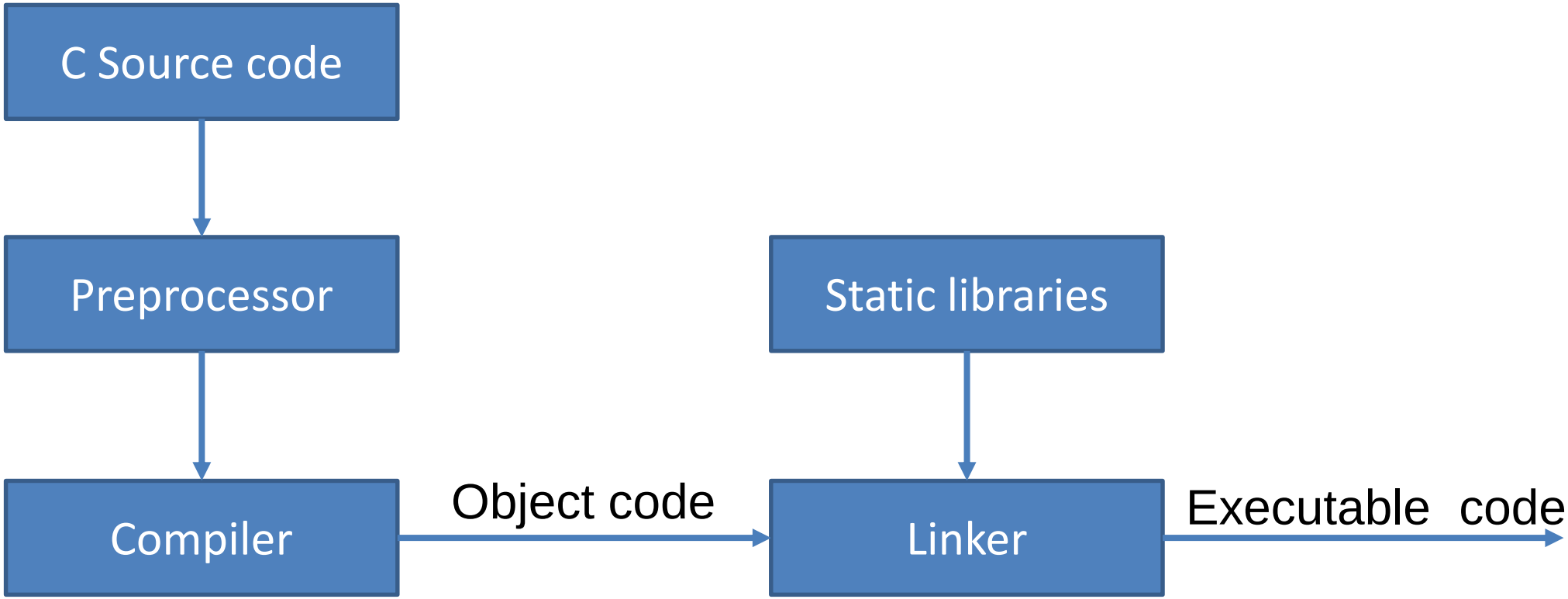
Fpt Software

C Preprocessor Overview

C Preprocessor Overview



C Preprocessor Overview

- The C pre-processor is a macro processor that is used by the C compiler to transform our program before it is compiled. It allows to define macros.
- The preprocessing consists of preprocessor directives to be executed and macros to be expanded:
    + Inclusion of header files.
    + Macro expansion.
    + Conditional compilation.
    + Diagnostics directives.
- Preprocessing directives are lines that start with '#' symbol.

Macro

Macro definition

What is macro

A *macro* is a fragment of code which has been given a name. Whenever the name is used, it is replaced by the contents of the macro

Macro is defined using #define preprocessor directive in the C language.

When to use

When creating constants that represent numbers, strings or expressions.

Macro classification

- Predefined macro
- User-defined macro

Object-like Macros

❑ Syntax

#define MACRO_NAME macro's body
#undef MACRO_NAME

- Give symbolic names to numeric constants
- The macro's body end at the end of the #define line
- Single line macro:

```
#define SIZE 10
```

- Multiple line macro:

```
#define NUMBERS  1, \
                 2
```

Object-like Macros

Use case

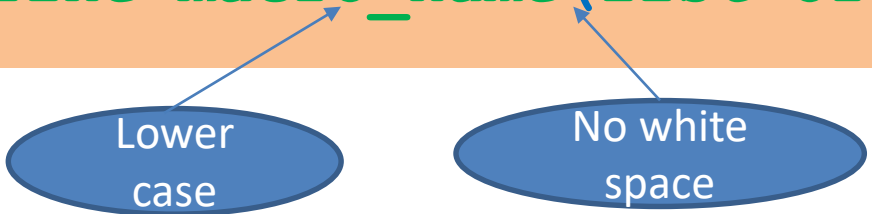
- Un-define and re-define:

```
#ifdef  TRUE
    #undef  TRUE
    #define TRUE 1
#endif
```

Function like Macros

Syntax

```
#define macro_name(list of parameters) macro's body
```



- Each parameter should guarded by parentheses.

```
#define mul(X, Y) ((X) * (Y))
x = mul(a, b); ==> x = ((a) * (b));
y = mul(1, 2); ==> y = ((1) * (2));
```

- Return wrong value if parentheses is not used for each parameter:

```
#define mul(X, Y) (X * Y)
y = mul(1+2, 2); ==> y = (1+2 * 2); /* return 5 */
```

Function like Macros

- Nesting macro can be used in an macro like function:

```
#define UART0_BDH_SBR_MASK      (0x1FU)
#define UART0_BDH_SBR_SHIFT     (0U)
#define UART0_BDH_SBR(x)        (((uint8_t)(((uint8_t)(x)) << \
UART0_BDH_SBR_SHIFT)) & UART0_BDH_SBR_MASK)
```

Function like Macros

- Compare macro and function:

Macro	Function
- Macro is Pre-processed and is replaced by macro value. - Using Macro increases the code size. - Application execution is faster - Useful when it is used to replace small code many times.	- Function is Compiled and use branch instruction when it is called. - Using Function will not increase the code size. - Application execution is lower. - Useful when large code is requested.

C Preprocessor Directives

Inclusion directive

- Syntax

  #include <*file*>

  #include "*file*"

  - <*file*> is used for system header files such as math.h, string.h, stdint.h…
  - "*file*" is used for header files of your own program.

Conditional compilation

- Syntax

```
#if <constant-expression>
#if defined MACRO_NAME
#ifdef MACRO_NAME
#if ! defined MACRO_NAME
#ifndef MACRO_NAME
#elif <constant-expression>
#else
#endif
```

Conditional compilation

Use case

- Avoid repeat inclusion header file:
  In MKL46Z4.h:

```
#ifndef _MKL46Z4_H_
        #define _MKL46Z4_H_

        /* Content of the header file */
#endif  /* _MKL46Z4_H_ */
```

Conditional compilation

Use case

- Disable and enable compile:

```
#if(UART_0_INIT_API == D_ON)
void UART0_Init()
{
    #ifdef UART_DMA_EXIST
        /* Enable DMA request */
        UART0->C5 |=  UART0_C5_RDMAE_MASK;
    #else
        /* Disable DMA request */
        UART0->C5 &=  UART0_C5_RDMAE_MASK;
    #endif
}
#endif
```

Diagnostics Directive

Syntax

```
#error "the error message"
#warning "the warning message"
```

- For "#warning": The pre-processor will continue pre-processing after the warning message appears.

Example:

```
#if !defined(DMA_EXIST) && defined(DMA_USED)
        #error "The DMA resource does not exist to use."
#endif
```

Condition Operator “?:”

- Syntax

<condition expression_1> ? <expression_2> : <expression_3>;

- The value of **expression_2** will be returned if **condition expression_1** is true.
- The value of **expression_3** will be returned if **condition expression_1** is false.
- Example:

```
#define min(X, Y) ((X) < (Y) ? (X) : (Y))
x = min(a, b); ==> x = ((a) < (b) ? (a) : (b));
y = min(1, 2); ==> y = ((1) < (2) ? (1) : (2));
```

Preprocessor Operators

- Stringizing operator (#)
  - Stringizing operator (**#**) converts macro parameters to string.
- Token pasting operator (##)
  - Used in a macro and the two tokens on either side of each '##' operator are combined into a single token.

Preprocessor Operators

- **Example:**

```
struct command {
   char *name;
   void (*function) (void);
};
#define COMMAND(NAME)  { #NAME, NAME ## _command }
struct command commands[] = {
   COMMAND (quit),
   COMMAND (help),
};
```

Token pasting preprocessing operator

Stringizing preprocessing operator

The result:

```
struct command commands[] = {
   { "quit", quit_command },
   { "help", help_command },
};
```

Bit Operations

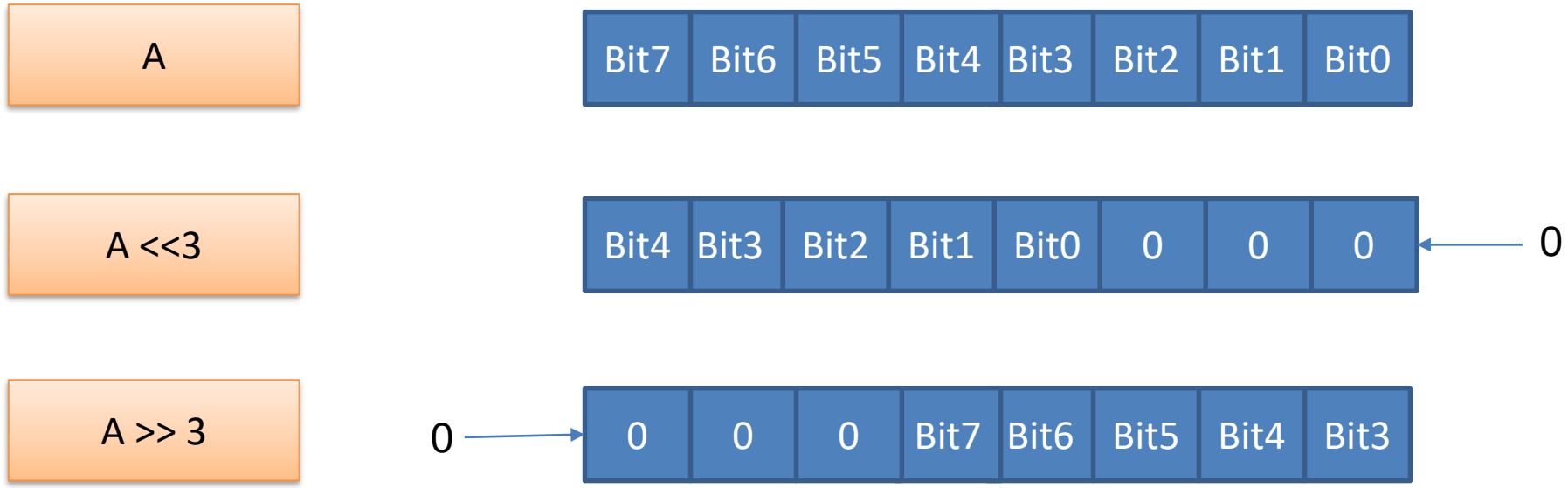
Bit Operations(1)

Symbol	Operation
&	AND
|	OR
^	XOR
~	NOT
<<	Left shift
>>	Right shift

Bit A	Bit B	A & B	A | B	A ^ B	~A
0	0	0	0	0	1
0	1	0	1	1	1
1	0	0	1	1	0
1	1	1	1	0	0

Bit Operations(2)

❑ Shift operations



Bit Operations(3)

- Examples:

A = 0xAA(0b10101010)

B = 0x0F(0b00001111)

A & B = 0x0A(0b00001010)

A | B = 0xAF(0b10101111)

A ^ B = 0xA5(0b10100101)

~A = 0x55(0b01010101)

A << 3 = 0x50(0b01010000)

B >> 3 = 0x01(0b00000001)

Bit Operations(4)

❑ Use case:

Bit	7	6	5	4	3	2	1	0
Read Write	LBKDIE	RXEDGIE	SBNS	SBR				
Reset	0	0	0	0	0	0	0	0

- Register mask for SBR bits field:

```
#define UART0_BDH_SBR_MASK          (0x1FU)
#define UART0_BDH_SBNS_MASK         (0x20U)
```

- Set SBNS bit:

```
UART0->BDH = (UART0->BDH) | UART0_BDH_SBNS_MASK;
```

- Clear SBNS bit:

```
UART0->BDH = (UART0->BDH) & (~UART0_BDH_SBNS_MASK);
```

- Read SBNS bit:

```
Var_SBNS = (UART0->BDH) & UART0_BDH_SBNS_MASK;
```

Bit Operations(5)

❑ Use case:

Bit	7	6	5	4	3	2	1	0
Read Write	LBKDIE	RXEDGIE	SBNS	SBR				
Reset	0	0	0	0	0	0	0	0

- Modify SBR bits field:

```
Var_SBR = 0x0E;
UART0->BDH = ((UART0->BDH) & (~UART0_BDH_SBR_MASK)) |
                        (Var_SBR & UART0_BDH_SBR_MASK);
```

- Example about Peripheral Access Layer in MKL46Z4.h file

Reference List

1. https://gcc.gnu.org/
2. https://en.wikipedia.org/
3. The C programming Language By Brian W. Kernighan and Dennis M. Ritchie.

Thanks for listening!