System-Level Programming

11 Preprocessor

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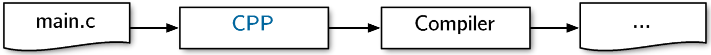
http://sys.cs.fau.de/lehre/ss25

The C Preprocessor [≠Python]



- Before a C source file is compiled, it is processed by the macro preprocessor
  - in the past, a stand-alone program (**CPP** = **C** **P**re**P**rocessor)
  - nowadays, integrated into compilers
- The CPP edits the source code by text transformations
  - automatic transformation ("clean-up" of the source code)
    - comments are deleted
    - lines ending with \ are put together
    - ...
  - controllable transformations (by the programmer)
    - preprocessor directives are evaluated and executed
    - preprocessor macros are expanded

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The preprocessor defines an embedded **meta language**. All preprocessor directives (i.e., the meta program) modify the C program (i.e., actual program) prior to actual compilation.

Preprocessor – Example

- Simple macro definitions

empty macro (flag)	`#define USE_7SEG`
source-code constant	`#define NUM_LEDS (4)`
“inline” function	`#define SET_BIT(m, b) (m | (1 << b))`

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- Usage

```
#if NUM_LEDS < 0 || 8 < NUM_LEDS
#  error invalid NUM_LEDS          // this line is not included
#endif

void enlighten(void) {
  uint8_t mask = 0, i;
  for (i = 0; i < NUM_LEDS; i++) {  // NUM_LEDS --> (4)
    mask = SET_BIT(mask, i);        // SET_BIT(mask, i) --> (mask | (1 << i))
  }
  sb_led_setMask(mask);             // --> ● ● ● ● ○ ○ ○ ○

#ifdef USE_7SEG
  sb_show_HexNumber(mask);          // --> 0F
#endif

}
```

Preprocessor – Risks

- Function-like macros are indeed no functions!
  - Parameters are not evaluated, rather they are expanded textually. Since CPP misses C semantics, expansions can lead to unwanted surprises.

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#define max(a, b) ((a > b) ? a : b)      a++ will be potentially evaluated twice
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- A possible alternative are real `inline` functions C99
  - function's body is directly inserted ⇝ as efficient as macros

```
inline int max(int a, int b) {
  return (a > b) ? a : b;
}
```