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Coding Guidelines

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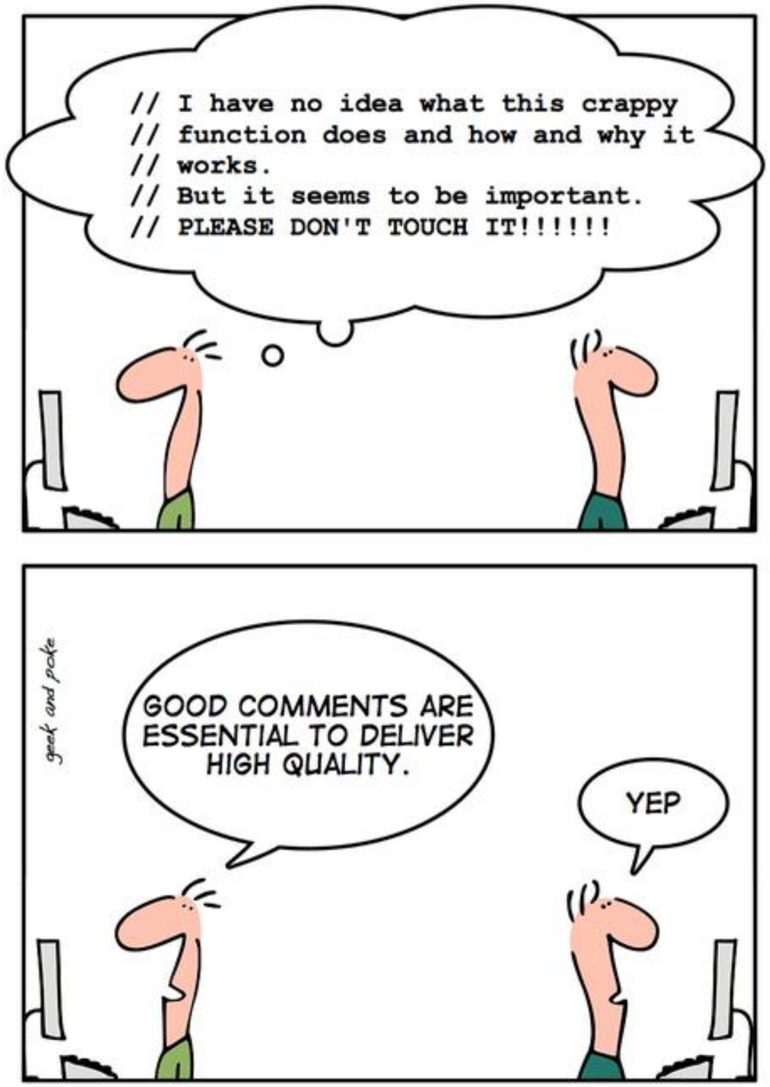
Motivation


// I have no idea what this crappy
// function does and how and why it
// works.
// But it seems to be important.
// PLEASE DON'T TOUCH IT!!!!!!
GOOD COMMENTS ARE ESSENTIAL TO DELIVER HIGH QUALITY.
YEP
geek and poke

Why Coding Guidelines?

- **Reduce the number of bugs**
  - Robustness
  - Correctness
  - Maintainability
- **Facilitate code reading within a team**
  - Takes less time to understand another team member's code
- **Improve portability**
  - Reuse of code on other HW platforms
- **Enforce by**
  - Automated scans (part of static code checking)
  - Peer reviews

Coding Guidelines

- **Rules are subjective**
  - Different organizations have different guidelines
- **"When in Rome do as the Romans do"**

Appearance

- **Indentation**
  - 4 Spaces, no Tabs
- **Maximum of 80 characters per line**
  - Print-outs
  - On-screen code diff
- **No more than one statement per line**
  - Readability and clarity
- **Use parentheses to aid clarity**
  - Do not rely on C's operator precedence rules
    - They may not be obvious to the maintainer

Braces

- **Non-function statement blocks**
  - `if, else, switch, for, while, do`
  - opening last on line
  - closing first on line
  - always use braces also for single statements and empty statements
    - reduces risk during code changes

```
    if (x == y) {
        p = q;
    }
```

```
~~    if (x == y)~~
~~        p = q;~~
```

Braces

- **Functions**
  - opening beginning of next line
  - closing first on line

```
int32_t function(int32_t x)
{
     body of function
}
```

Braces

- **The closing brace is empty on a line of its own,**
  - except in cases where it is followed by a continuation of the same statement
    - e.g. a "while" in a do-statement or an "else" in an if-statement

```
do {
    body of do-loop
} while (condition);
```

```
if (x == y) {
    ...
} else if (x > y) {
    ...
} else {
    ...
}
```

Braces

- **struct / enum**

```
    typedef enum {
        RED,
        GREEN
    } colors;
```

```
    struct entry {
        uint32_t index,
        uint32_t value
    };
```

Spaces

- **Mostly function-versus-keyword usage**
- **Use space after keywords**
  - if, switch, case, for, do, while
- **No space with sizeof, typeof, alignof, or attribute**
  - as they look somewhat like functions

```
s = sizeof(struct file);
```

- **Pointer declaration**
  - * adjacent to data name or function name

```
uint8_t *ptr;
uint32_t parse(uint8_t *ptr, uint8_t **retptr);
uint8_t *match(uint8_t *s);
```

Spaces

- **Use one space on each side of binary and ternary operators**

```
=    +    -    <    >    *    /    %    |
&    ^    <=   >=   ==   !=   ?    :
```

- **No space after unary operators**

```
&  *  +  -  ~  !  sizeof  typeof
alignof  __attribute__  defined
```

Spaces

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- No space before postfix unary operators

```
i++;
p--;
```

- No space after prefix unary operators

```
++i;
--p;
```

- No space around the '.' and "->" structure member operators
- Do not leave trailing whitespaces

Functions

- **Short and sweet**
  - i.e. no more than about 50 lines of code
- **Do just one thing**
- **No more than 5-10 local variables**
- **No more than 3 parameters**
- **Function prototypes shall include parameter names with their data types**
- **No more than 3 levels of indentation**

Functions

- **Use `const` to define call-by-reference function parameters that should not be modified**
  - `int32_t strlen(const int8_t s[]);`
    - strlen() does not modify any character of character array s
  - `void display(mystruct const *param);` [1]

1) Same as `void display(const mystruct *param);`

Functions

- **Just one exit point and it shall be at the bottom of the function**
  - keyword **`return`** shall appear only once
- **All <u>'private' functions</u> shall be defined `static`**
  - 'private' → Functions that are only used within the module itself. The function is an implementation detail and not accessible from other modules
- **A prototype shall be defined for each <u>'public' function</u> in the module header file `module.h`**
  - 'public' → Functions that are called by other modules. The function prototypes are part of the module interface.

Return Values

- **Shall be checked by the caller**

- **If the name of a function is an action or an imperative command**
  - Function should return an error-code integer i.e. 0 for success and -Exxx for failure.
    - If possible error codes shall be based on the Posix Errorcode
    - If self-defined error codes are being used they shall be properly documented. In the header file for public functions or in the .c file for private functions
    - For example, "add work" is a command, and the `add_work()` function returns 0 for success or -EBUSY for failure.

Return Values

- **If the name of a function is a predicate**
  - Function should return a "succeeded" boolean.
  - "PCI device present" is a predicate, and the `pci_dev_present()` function returns 1 if it succeeds in finding a matching device or 0 if it doesn't.
- **Functions whose return value is the actual result of a computation, rather than an indication of whether the computation succeeded, are not subject to this rule.**
  - Generally they indicate failure by returning some out-of-range result.
  - Typical examples would be functions that return pointers; they use NULL or the ERR_PTR mechanism to report failure.

Naming

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- No macro name (`#define`) shall contain any lowercase letters
- Function and variable names shall not contain uppercase letters
- Use descriptive names for functions, global variables and important local variables
- Underscores shall be used to separate words in names e.g. `count_active_users()`
- Use short names e.g. i for auxiliary local variables like loop counters
- Do not encode types in names. Let the compiler do the type checking

Comments

- **All comments shall be in English**
- **C99 comments // are allowed**
- **Explain WHAT your code does not HOW**
  - Don't repeat what the statement says in a comment.
  - Assume that the reader is familiar with C
- **Comments shall never be nested**
- **All assumptions shall be spelled out in comments**
  - or even better in a set of design-by-contract tests or assertions
- **The interface of a public function shall be commented next to the function prototype in the header file.**
  - The comment shall not be repeated next to the function definition in the .c file

Types

- **Use fixed width C99 data types from `stdint.h`**
  - e.g. **`uint8_t`** or **`int32_t`** rather than **`unsigned char`** or **`int`**
- **Type char shall be restricted to declarations and operations on strings**
- **Bit-fields shall not be defined within signed integer types**
- **None of the bit-wise operators shall be used to manipulate signed integer data**
  - i.e. do not use `&`, `|`, `~`, `^`, `<<` and `>>` on signed integers

Types

- **Signed integers shall not be combined with unsigned integers in comparisons or expressions**
  - Decimal constants meant to be unsigned should be declared with an 'U' at the end
- **Casts shall be done explicitly and accompanied by a comment**
- **Use just one data declaration or one data definition per line**
  - Allows a comment for each item.

Header Files

- **There shall be precisely one header file for each module**
- **Each header file shall contain a preprocessor guard against multiple inclusion**

```
#ifndef _ADC_H
#define _ADC_H
...
#endif    /* _ADC_H */
```

- **Only add #includes that are immediately needed for this header file; do not add #includes for convenience of others**
- **Do not define or declare variables**
  - i.e. `uint32_t count / extern uint32_t count`

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Coding Techniques

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Module Traffic Light

Encapsulation

- Interface → .h
- Implementation → .c

.h contains the module interface

traffic_light.h

```
typedef enum {
    DARK    = 0x00,
    RED     = 0x01,
    YELLOW  = 0x02,
    GREEN   = 0x03
} tl_state_type;

/** Set-up and initializes the traffic light */
void traffic_light_init(void);

/** Sets the specified state on the traffic light */
void traffic_light_set_state(tl_state_type state);

/** Returns the current state of the traffic light */
tl_state_type traffic_light_get_state(void);
```

traffic_light.h contains only those function declarations (prototypes) and type definitions that are strictly necessary for another module to know.

Module TL

.c contains the implementation

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traffic_light.c

```c
#include "traffic_light.h"

static tl_state_type traffic_light_state;
static void lamps_set(tl_state_type color);

/** See description in header file */
void traffic_light_init(void){
    traffic_light_state = DARK;
    lamps_set(DARK);
}

/** See description in header file */
void traffic_light_set_state(tl_state_type state){
    traffic_light_state = state;
    lamps_set(state);
}

/** See description in header file */
tl_state_type traffic_light_get_state (void){
    return traffic_light_state;
}

/** Turns the individual lamps on and off */
static void lamps_set(tl_state_type state){
    // drive the lamps
}
```

Variable `traffic_light_state` and function `lamps_set()` are declared `static`
→ visible only inside module traffic_light

Module Traffic Light

- **Caveat**
  - Example module *'traffic_light'* can only be used for a single instance of a traffic light
  - Reason: **`traffic_light_state`** is a **`static`** variable
  - In many embedded use cases having a single instance is fine
  - But what if I have more than one traffic light?

Module Traffic Light

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Possible approach

- Include a static variable for each traffic light

```
static tl_state_type tl_state_pedestrian;
static tl_state_type tl_state_cars;
```

- Requires an additional parameter in many of the functions

```
typedef enum {
    PEDESTRIAN,
    CARS
} tl_instance_type;

void traffic_light_set_state(tl_state_type state,
                             tl_instance_type instance){
```

- Alternatively an array of traffic lights could be used

```
static tl_state_type tl_state[5];
```

Module Traffic Light

- **Now more than one traffic light is possible**
  - But each time we add an instance of a light we need to change the module *traffic_light*
- **Possible approach**
  - Extract the traffic light state from module *traffic_light* and let the module using *traffic_light* allocate the memory

module using traffic_light

```
#include traffic_light.h

int32_t main(void) {
    tl_state_type ped_light;

    void traffic_light_init(&ped_light);
    void traffic_light_set_state(&ped_light, RED);
    ...
}
```