Carnegie Mellon University

Electrical & Computer ENGINEERING

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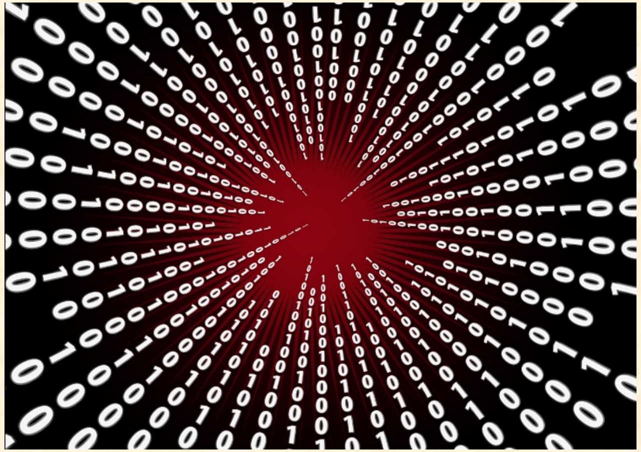
Code Style for Compilers

“Programming can be fun, so can cryptography; however they should not be combined.”
– *Kreitzberg and Shneiderman*

Coding Style: Language Use

- Anti-Patterns:
  - Code compiles with warnings
  - Warnings are turned off or over-ridden
  - Insufficient warning level set
  - Language safety features over-ridden



- Make sure the compiler understands what you meant
  - A warning means the compiler might not do what you think
    - Your particular language use might be “undefined”
  - A warning might mean you’re doing something that’s likely a bug
    - It might be valid C code, but should be avoided
  - Don’t over-ride features designed for safe language use

The C Language Doesn't Always Play Nice

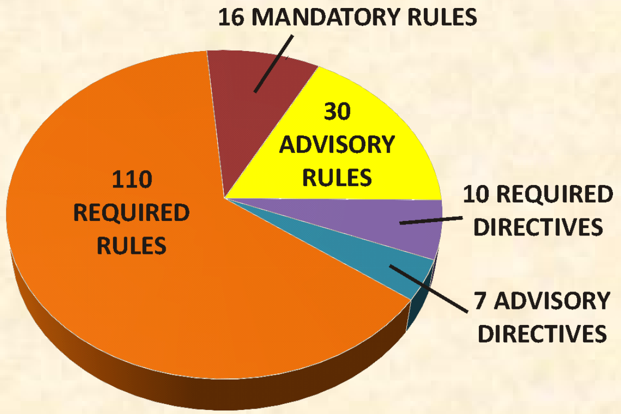
- Defined, but potentially dangerous
  - `if (a = b) { … }                    // a is modified`
  - `while (x > 0);   {x = x-1;}   // infinite loop`

- Undefined or unspecified ➔ dangerous
  - You might think you know what these do …

    … but it varies from system to system
  - `int *p = NULL;   x = *p;        // null pointer dereference`
  - `int b;    c = b;                // uninitialized variable`
  - `int x[10]; …   b = x[10];     // access past end of array`
  - `x = (i++) + a[i];               // when is i incremented?`

Language Use Guidelines & Tools

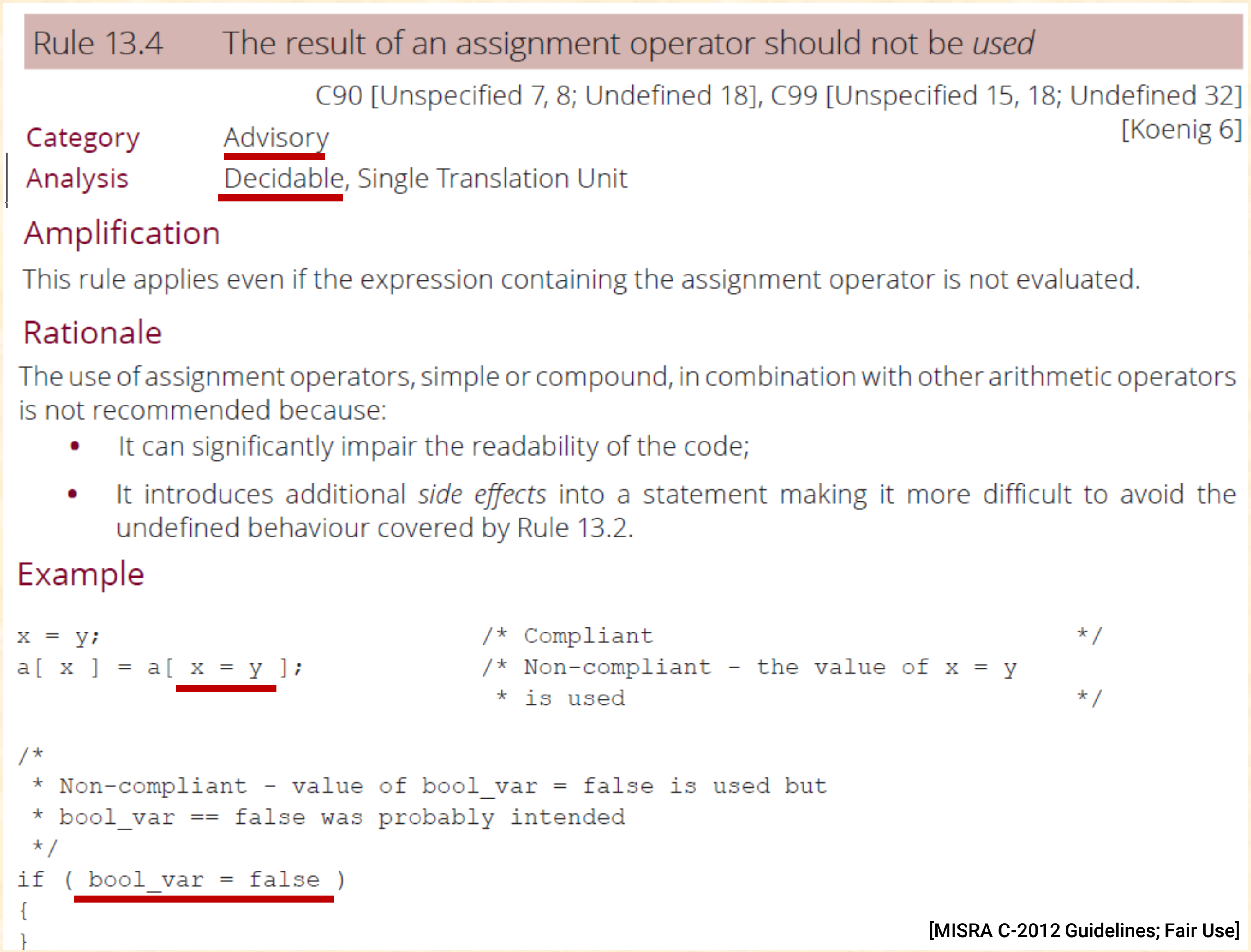
- MISRA C, C++
  - Guidelines for critical systems in C (e.g., no malloc)
  - Portability, avoiding high risk features, best practices
- CERT Secure C, C++, Java
  - Rules to reduce security risks (e.g., buffer overflows)
  - Includes list of which tools check which rules



MISRA C:2012 with Security

- Static analysis tools
  - More than compiler warnings (e.g., strong type warnings)
  - Many tools, both commercial and free. Start by going <u>far</u> past "–Wall" on gcc
- Dynamic Analysis tools
  - Executes the program with checks (e.g., memory array bounds)
  - Again, many tools. Start by looking at Valgrind tool suite

MISRA C 2012 Example



Rule 13.4 The result of an assignment operator should not be *used*

C90 [Unspecified 7, 8; Undefined 18], C99 [Unspecified 15, 18; Undefined 32] [Koenig 6]

Category	Advisory
Analysis	Decidable, Single Translation Unit

Amplification

This rule applies even if the expression containing the assignment operator is not evaluated.

Rationale

The use of assignment operators, simple or compound, in combination with other arithmetic operators is not recommended because:

- It can significantly impair the readability of the code;
- It introduces additional *side effects* into a statement making it more difficult to avoid the undefined behaviour covered by Rule 13.2.

Example

```
x = y;                          /* Compliant                            */
a[ x ] = a[ x = y ];            /* Non-compliant - the value of x = y
                                 * is used                              */

/*
 * Non-compliant - value of bool_var = false is used but
 * bool_var == false was probably intended
 */
if ( bool_var = false )
{
}
```

[MISRA C-2012 Guidelines; Fair Use]

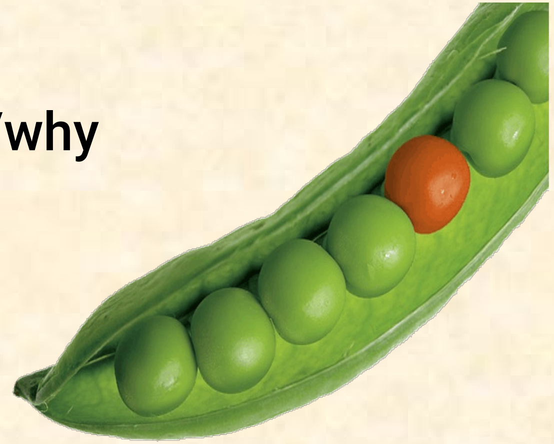
Let the Language Help!

- Use enum instead of int
  - `enum color {black, white, red}; // avoids bad values`
- Use const instead of #define

  -
    ```
    const uint64_t x = 1; // helps with type checking
    uint64_t y = x << 40; // avoids 32-bit overflow bug
    ```
- Use inline instead of #define
  - If it's too big to inline, the call overhead doesn't matter
  - Many compilers inline automatically even without keyword
- Use typedef with static analysis

  -
    ```
    typedef uint32_t feet; typedef uint32_t meters;
    feet   x = 15;
    meters y = x;  // feet to meters assignment error
    ```
- Use stdint.h for portable types
  - int32_t is 32-bit integer, uint16_t is 16-bit unsigned, etc.

Deviations & Legacy Code



- Use deviations from rules with care
  - Use “pragma” deviations sparingly; comment what/why
- What about legacy code that generates lots of warnings?
  - Strategy 1: fix one module at a time
    - Useful if you are refactoring/re-engineering the code
    - Sometimes might need to keep warnings off for 3rd party headers
  - Strategy 2: turn on one warning at a time
    - Useful if you have to keep a large codebase more or less in synch
  - Strategy 3: start over from scratch
    - If the code is bad enough this is more efficient … if business conditions permit

Or – You Can Use A Better Language!

- Desirable language capabilities:
  - Type safety and strong typing (e.g., pointers aren't ints)
  - Memory safety (e.g., bounds on arrays)
  - Robust static analysis (language & tool support)
  - In general, no surprises

```
procedure Increment (X : in out Counter_Type)
  with Global   => null,
       Depends  => (X => X),
       Pre      => X < Counter_Type'Last,
       Post     => X = X'Old + 1;
```

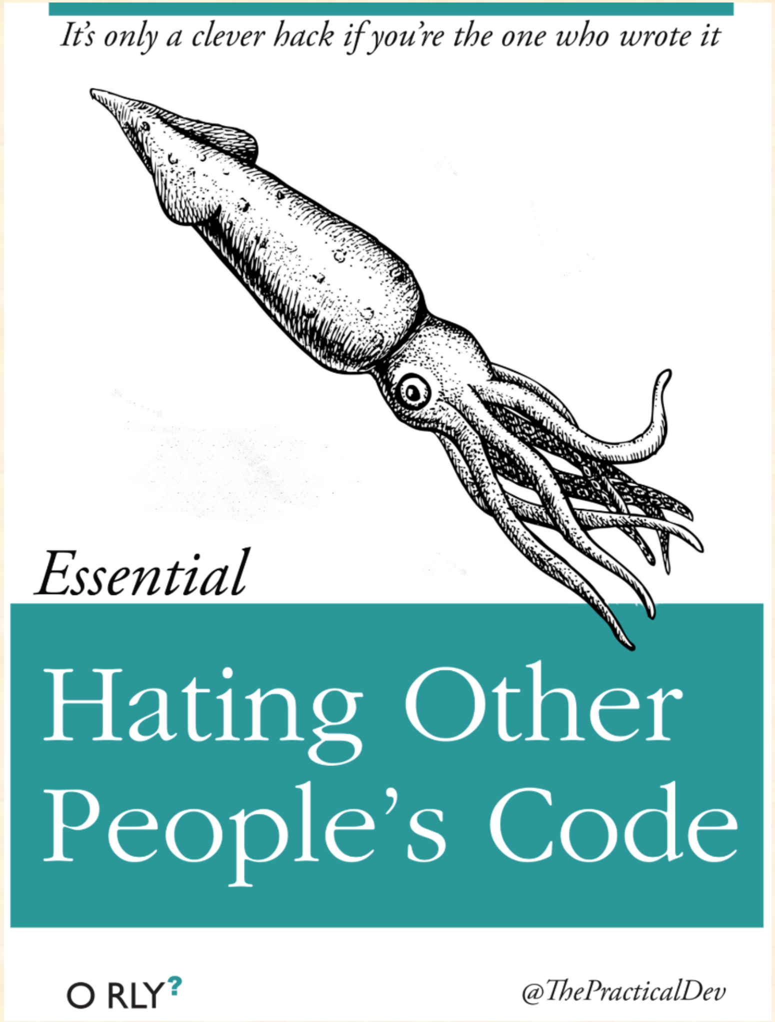
- Spark Ada as a safety critical language
  - Formally defined language; verifiable programs
    - The language doesn't have ambiguities or undefined behaviors
  - You can prove that a program is correct
    - E.g., can prove absence of: array index out of range, division by zero
    - (In practice, this makes you clean up your code until proof succeeds)
  - Key idea: design by contract
    - Preconditions, post-conditions, side effects are defined

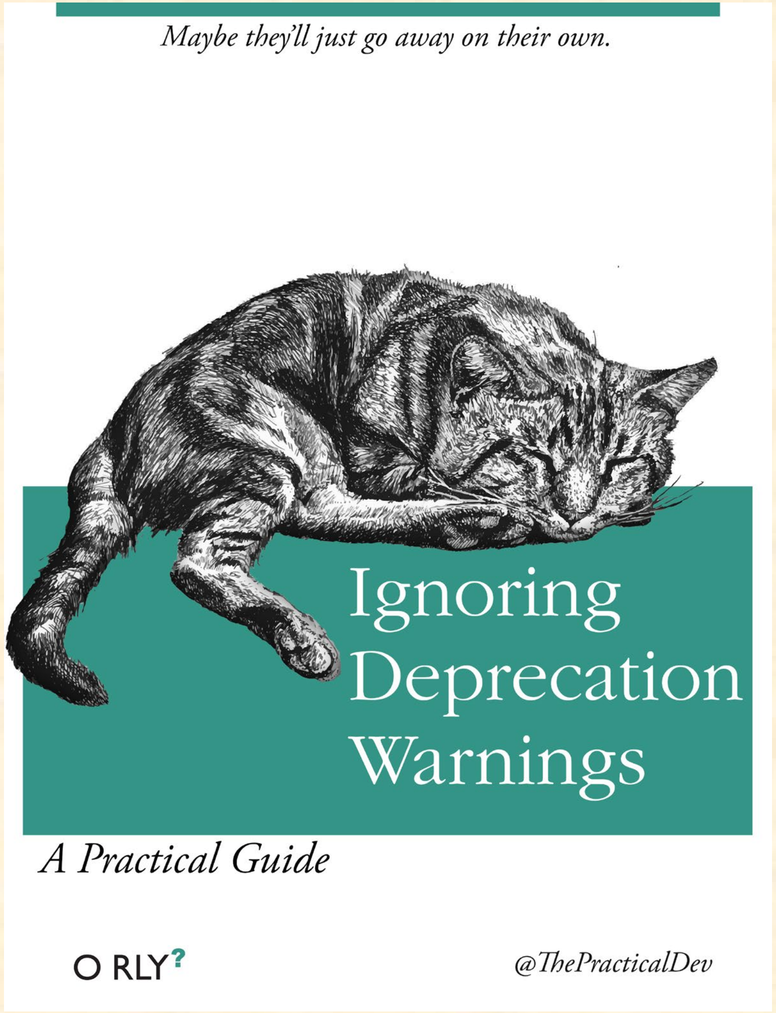
Wikipedia
https://goo.gl/3w6RF6

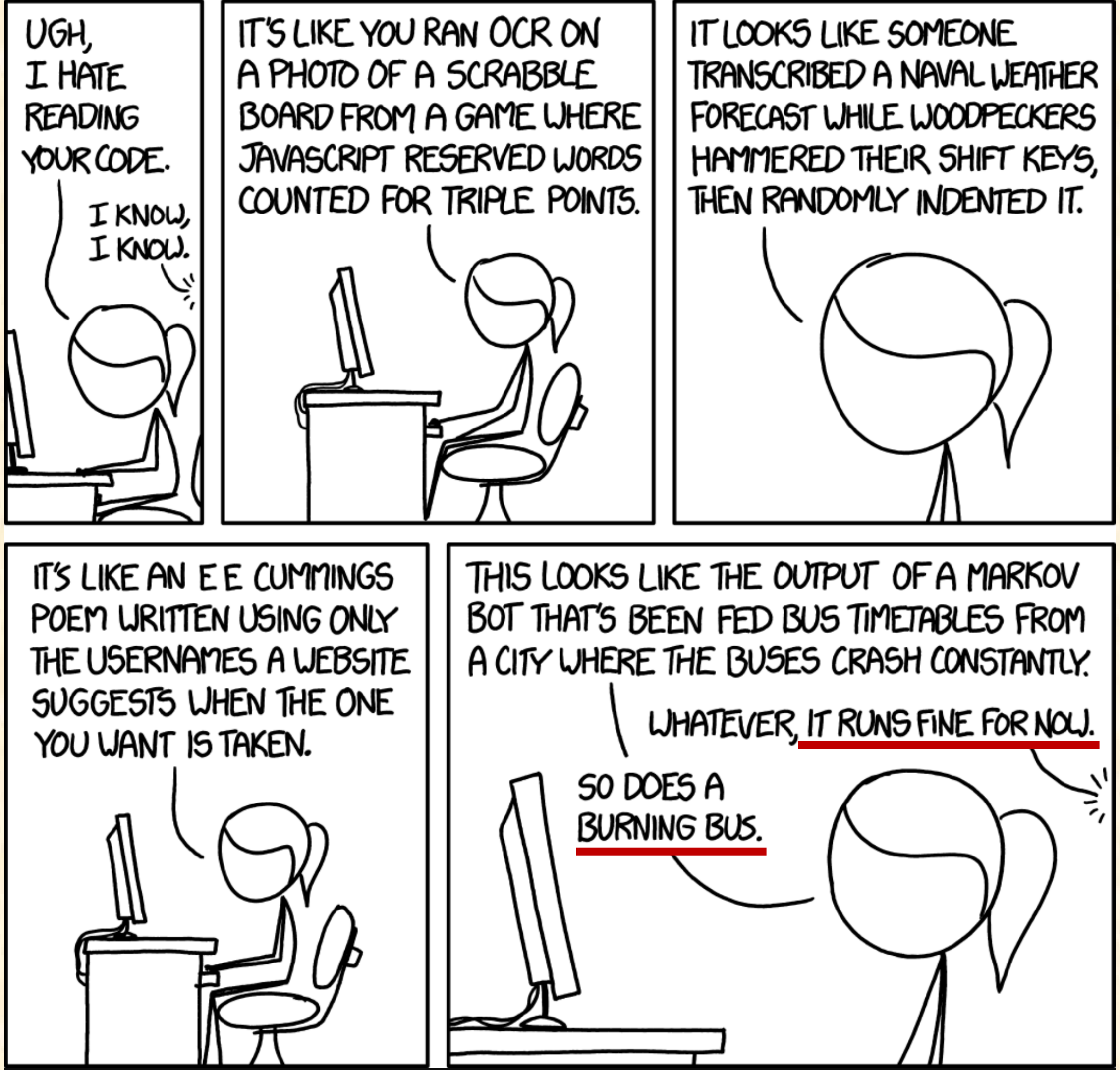
Spark Ada is a subset of the Ada programming language.

Language Style Best Practices

- Adopt a safe coding style (or a safe language)
  - MISRA C & CERT C are good starting points
  - Specify a static analysis tool and config settings
    - To degree practical, let machines find the style problems
  - When static analysis is set up, add dynamic analysis
- The point of good style is to avoid bugs
  - Let the compiler find many bugs automatically
  - Reduce chance of compiler mistaking your intention
- Coding style pitfalls:
  - "The code passes tests, so warnings don't matter"
  - Real bugs lost in a huge mass of warnings
  - Making it too easy to deviate from style rules


It's only a clever hack if you're the one who wrote it
Essential
Hating Other People's Code
O RLY?
@ThePracticalDev


Maybe they'll just go away on their own.
Ignoring Deprecation Warnings
A Practical Guide
O RLY?
@ThePracticalDev


UGH, I HATE READING YOUR CODE.
I KNOW, I KNOW.
IT'S LIKE YOU RAN OCR ON A PHOTO OF A SCRABBLE BOARD FROM A GAME WHERE JAVASCRIPT RESERVED WORDS COUNTED FOR TRIPLE POINTS.
IT LOOKS LIKE SOMEONE TRANSCRIBED A NAVAL WEATHER FORECAST WHILE WOODPECKERS HAMMERED THEIR SHIFT KEYS, THEN RANDOMLY INDENTED IT.
IT'S LIKE AN E E CUMMINGS POEM WRITTEN USING ONLY THE USERNAMES A WEBSITE SUGGESTS WHEN THE ONE YOU WANT IS TAKEN.
THIS LOOKS LIKE THE OUTPUT OF A MARKOV BOT THAT'S BEEN FED BUS TIMETABLES FROM A CITY WHERE THE BUSES CRASH CONSTANTLY.
WHATEVER, IT RUNS FINE FOR NOW.
SO DOES A BURNING BUS.

https://xkcd.com/1695/