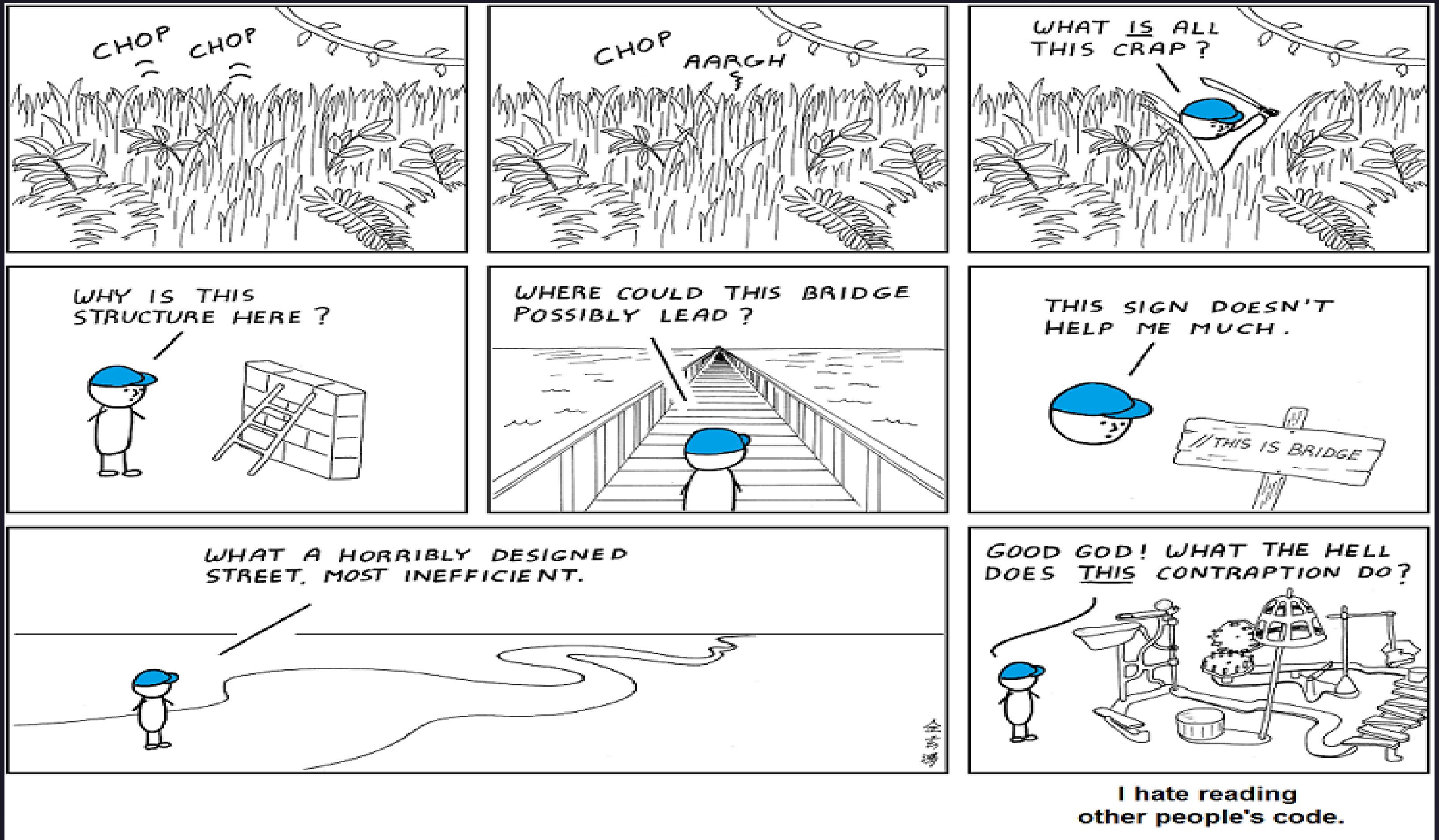
Do More with Less Work when You Code

Ofir Pele

Others Code – What Does It Feel Like?



From: [Abstruse Goose Archive]

Good Code – What Does It Feel Like?

Adapted from: https://xkcd.com/353/

Good Code – "I Know It When I See It"

Potter Stewart, 1964

How to Be a Good Programmer

- 😘 KISS: Keep It Simple, Stupid
- 🏜️ DRY: Don't Repeat Yourself (and Others)
- 🚮 YAGNI: You Aren't Gonna Need It (and You Don't Need It Anymore)

How to Be a Good Programmer

- Break problems down
- Code should be:

  easy to use correctly

  and

  hard to use incorrectly
- Test before implementation:

  easy to test ⇒ easy to use

Program Style

Program Style

- **Very important** - Take the time for it
- If not followed, your code will be "write only"
- Common sense
- Use formatters, linters, ... e.g., ruff, ty
- Refactor: rewrite, more on this later
- (Optional) Read "real" coding guidelines – will give you insight into how important it is
  - e.g., Microsoft or Google

What's in a Name – Constants

Bad:

```
#define ONE 1
#define TEN 10
#define TWENTY 20
```

Good:

```
#define INPUT_MODE 1
#define INPUT_BUFSIZE 10
#define OUTPUT_BUFSIZE 20
```

What's in a Name – Descriptive Names

```
auto num_pending = 0;
```

What's in a Name – Naming Conventions

Naming conventions vary (style):

- `num_pending`
- `numPending`
- `NumberOfPendingEvents`

Be consistent, use ruff

What's in a Name – Wording

- `noOfItemsInQ`
- `frontOfTheQueue`
- `queueCapacity`

The word "queue" appears in 3 different ways

What's in a Name – Short *vs.* Long & Idioms

Bad Example:

```
auto elementArray = vector<int>(numberOfElements, 0);
for (theElementIndex = 0; theElementIndex < numberOfElements; theElementIndex++)
    elementArray[theElementIndex] = theElementIndex;
```

Idiom (but not perfect):

```
auto x = vector<int>(n, 0);
for (size_t i = 0; i < x.size(); ++i) {
    x[i] = i;
}
```

What's in a Name – Short *vs.* Long & Idioms

One modern idiom:

```
auto x = vector<int>(n, 0);
for (auto& x_i : x) {
    x_i = i;
}
```

Idiom in Armadillo library:

```
vec x = regspace(0, n);
```

What's in a Name – Short *vs.* Long & Idioms

Bad Example:

```
x = []
for _ in range(n):
    x.append(element_index)
```

Idioms:

```
x = list(range(n))
x = [(i) for i in range(n)]
x = np.arange(n)
```

What's in a Name – Active Names

Use active names for functions:

```
if (isdigit(c)) ...      // ✅ clear
if (checkdigit(c)) ...   // ❌ unclear
```

Accurate active names make bugs apparent

Indentation – Show Structure

Bad:

```
for(size_t i=0; i <100; x[i++] = 0);
   c = 0; return '\n';
```

Better (but still not good):

```
for (size_t i = 0; i < 100; i++) {
    x[i] = 0;
}
c = 0;
return '\n';
```

Statements – Use Indentation and Braces in C/C++

Bad:

```
if (i < 100) x = i; i++;
```

Better (but still not good):

```
if (i < 100) {
    x = i;
}
i += 1;
```

Expressions – Use Parentheses

Bad:

```
leap_year = y % 4 == 0 && y % 100 != 0
            || y % 400 == 0;
```

Good:

```
leap_year = ((y % 4 == 0) && (y % 100 != 0))
            || (y % 400 == 0);
```

Use Else-If Chains for Multiway Decisions

```
if (cond1) {
    statement1;
} else if (cond2) {
    statement2;
} else if (cond3) {
    statementn;
} else {
    default_statement;
}
```

Flatten Nested Conditions

Nested, Bad:

```
if (x > 0)
    if (y > 0)
        if (x + y < 100) { ... }
        else printf("Sum too large!\n");
    else printf("y too small!\n");
else printf("x too small!\n");
```

Flatten Nested Conditions

Flat, Good:

```c
if (x <= 0) {
    printf("x too small!\n");
} else if (y <= 0) {
    printf("y too small!\n");
} else if (x + y >= 100) {
    printf("Sum too large!\n");
} else {
    ...
}
```

C Switch

```c
switch (direction) {
    case NORTH: y++; break;
    case SOUTH: y--; break;
    case EAST:  x++; break;
    case WEST:  x--; break;
    default:    printf("Invalid direction!\n"); break;
}
```

Python Match

```python
match direction:
    case "north":
        y += 1
    case "south":
        y -= 1
    case "east":
        x += 1
    case "west":
        x -= 1
    case _:
        raise AssertionError
```

Comments – Don't State the Obvious

Bad:

```
// return SUCCESS
return SUCCESS;

// Initialize total to number_received
total = number_received;
```

Rewrite Bad Code Instead of Explaining It

Bad:

```
// If result = 0 a match was found so return
// true; otherwise return false;
return !result;
```

Good:

```
return is_match;
```

Code Tells a Story

Every line (or at least several lines)

should be **self-explanatory**

about **what** it does

even if we don't understand **how**

Refactoring

Rewriting your code to improve style is

very important

Style Recap

- Descriptive names
- Clarity in expressions
- Straightforward flow
- Readability of code & comments (DRY)
- Consistent conventions & idioms
- Refactoring to improve

Why Bother?

Good style:

- Easy to understand code
- Smaller & polished
- Makes errors apparent

Sloppy style:

- Hard to read
- Broken flow
- Harder to find and correct errors

Assert

Assert – When to Use

Use for:

- Catching bugs

Don't use for:

- Checking user input
- Memory allocation requests
- External data validation

Assert – Example

```
#include <cassert>

double sqrt(double x) {
    assert(x >= 0);
    ...
}
```

Assert – Benefits

- Declare implicit assumptions
- Sanity checks in code
- Check for violations during debugging/testing
- C/C++: zero cost at runtime
- Python: comment out / delete lines starting with assert

Compiling Warnings, Linters, Formatters

Why Do We Need Compiling Warnings, Linters, Formatters

"Keep us safe, as if we are children"

Written by Bezalel Aloni and sung by Ofra Haza

Tools

- C/C++: Add `-Wall` flag to catch things like this:

```
if (i = 0) {  // bug, we meant i == 0
    ...
}
```

- Python: ruff, ty
- **Legal but probably a bug** – the compiler/linter will warn you
- Force **consistency**

Test Driven Development

The Testing Problem

Programmers should write tests

But few do. Why?

- "I am so busy"
- "It is difficult"

Why Use a Testing Framework?

Disadvantages:

- "I need to learn a new thing" – *True, but done once, and it is very simple*
- "You don't have time for all that extra work" – *False*

Experiments repeatedly show that test suites **reduce debugging time** more than the time spent building the test suite

Advantages of Test Suites

- Many fewer bugs
- Easier to catch bugs if you have them
- A lot easier to maintain and modify your program

This is a **huge win** for programs that, unlike class assignments, get actual use!

Recommended TDD Approach

1. Design your code and write a stub for all functions
2. Write tests that fail for all functions
    - If hard to use the functions → return to step 1
3. For all units (functions, classes, etc.):
    - For all usage scenarios:
        - Write a test for the scenario
        - Replace stub with code, just enough to pass the test
        - Run the test
        - If fails, debug until it passes
4. Whenever you change code or find a bug → add a test

Refactoring

- **Purpose:** Make code easier to understand, more efficient (only if needed!)
- **Why needed:** Code tends to become messy
- **Rule:** Should not change the functionality
- **Benefit:** Automated testing simplifies refactoring – you can verify the changed code still passes tests

Unit Tests – What They Are

- Test each unit of a program **separately**
- Test that it fulfills its **contract**
- Writing tests – part of the coding (before implementation)
- Running tests – part of the build process
- Tests produce output only when they fail

Unit Tests – What They're Good For

- Save debugging time
- Find problems in design early
- Help build modular code
    - *If hard to find units → not modular*
- Make refactoring easy
- Easier to work in teams
- Live documentation (*vs.* dead and smelly)
- Everybody writes some kind of tests – using a framework saves time

Black Box Testing

Checks only that the **output is as expected** for the input, without checking internals

Example: Test an efficient and complex algorithm against a simple, obviously correct implementation

Debugging

Debugging 101

- **Define** the bug – reproduce it
- Use debugger and/or printouts (and other tools like valgrind)
- **Don't panic** – think!
- **Divide & Conquer**
- **Test before** instead of debugging after
- **Add test** for bug once fixed

Debugger

Features:

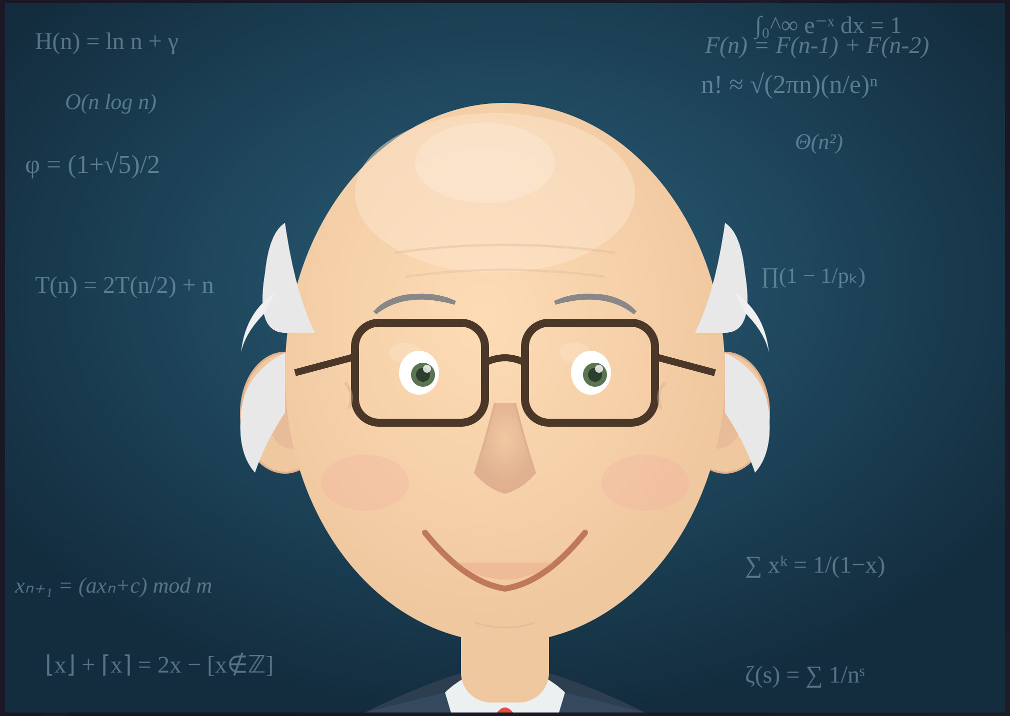
- See how the program runs and the value of variables
- Breakpoints, break on expression changes
- Stack trace: very helpful for seg faults

⚠️ **Danger:** Debuggers (and AI) tend to make people **not think** about the problem

Many excellent programmers don't use a debugger – they use "debugging in your mind"

Optimization

On Premature Optimization



"**Premature** optimization is the root of all **evil**"

Donald Knuth

So What to Do?

1. **Check if you need to optimize**
2. **Profile:** check where to optimize
3. Use a **compiled language** (C++, Rust, etc.)
4. Remember to **turn off debugging** (`#define NDEBUG`)
5. Check what your **compiler can do** for you on your specific hardware
   - `-O3 -march=pentium4 -mfpmath=sse`
   - Function inlining
6. Use common techniques (cache, etc.)

Number Representations

Important: Check, Don't Guess

If you need to know the representation – **check, don't guess**

Integer *vs.* Floating Point

```
1   + 2   == 3    # TRUE ✅
0.1 + 0.2 == 0.3  # FALSE ❌
```

Special Floating Point Values

```
1.0 / 0.0 == 1.0 / 0.0  # TRUE ✅ (C++, numpy)
                        # Exception 💣 (Python)

0.0 / 0.0 == 0.0 / 0.0  # FALSE ❌ (C++, numpy)
                        # Exception 💣 (Python)
```

Beware of Edge Cases

- **Overflows** and **rounding errors** (numeric stability)
- **Comparison with `==` for floating point**

Remember the special values and beware of unexpected behaviors:

- `NaN != NaN`
- IEEE 754 has signed zeros: `-0.0` and `+0.0`

Integer-Float Conversion Limits

- We won't necessarily be able to represent all integers A with floating-point B
- Even if $\#\text{bits}(A) \leq \#\text{bits}(B)$
- We can represent integers up to $2^{(\text{mantissa bits}+1)} + 1$

Program Design

Interfaces

A definition of a set of functions that provide a coherent module (or library):

- **Data structure** (e.g., list, binary tree)
- **User interface** (e.g., drawing graphics)
- **Communication** (e.g., device driver)

Interface — Modularity

Hide the implementation details of the module from its users

- **Specification** – "what"
- **Implementation** – "how"

Interface — Information Hiding

Hide "private" information from the outside:

- The "outside" program should not be able to use internal variables of the module
- Crucial for modularity

Resource management:

- Define who controls allocation of memory (and other resources)

Interface Principles — Hide Implementation

Hide data structures:

- Don't provide access to data structures that might be changed in alternative implementations
- A "visible" detail cannot be later changed without changing code using the interface

Interface Principles — Minimal Primitives

Use a small set of "primitive" actions:

- Provide a minimal set of operations to maximize functionality
- Don't provide unneeded functions "just because you can"

How much functionality?

- **Minimal** – for a few users, don't waste your time
- **Maximal** – when many users will use it (e.g., OS)

Interface Principles — No Surprises

Don't reach behind the back:

- Don't use global variables unless you must
- Don't have unexpected side effects
- Enforce assumptions

Interface Principles — Consistency

Do similar things in a similar way

```
strcpy(dest, source);
memcpy(dest, source, n);
```

Both follow the same parameter order convention

Interface Principles — Resource Management

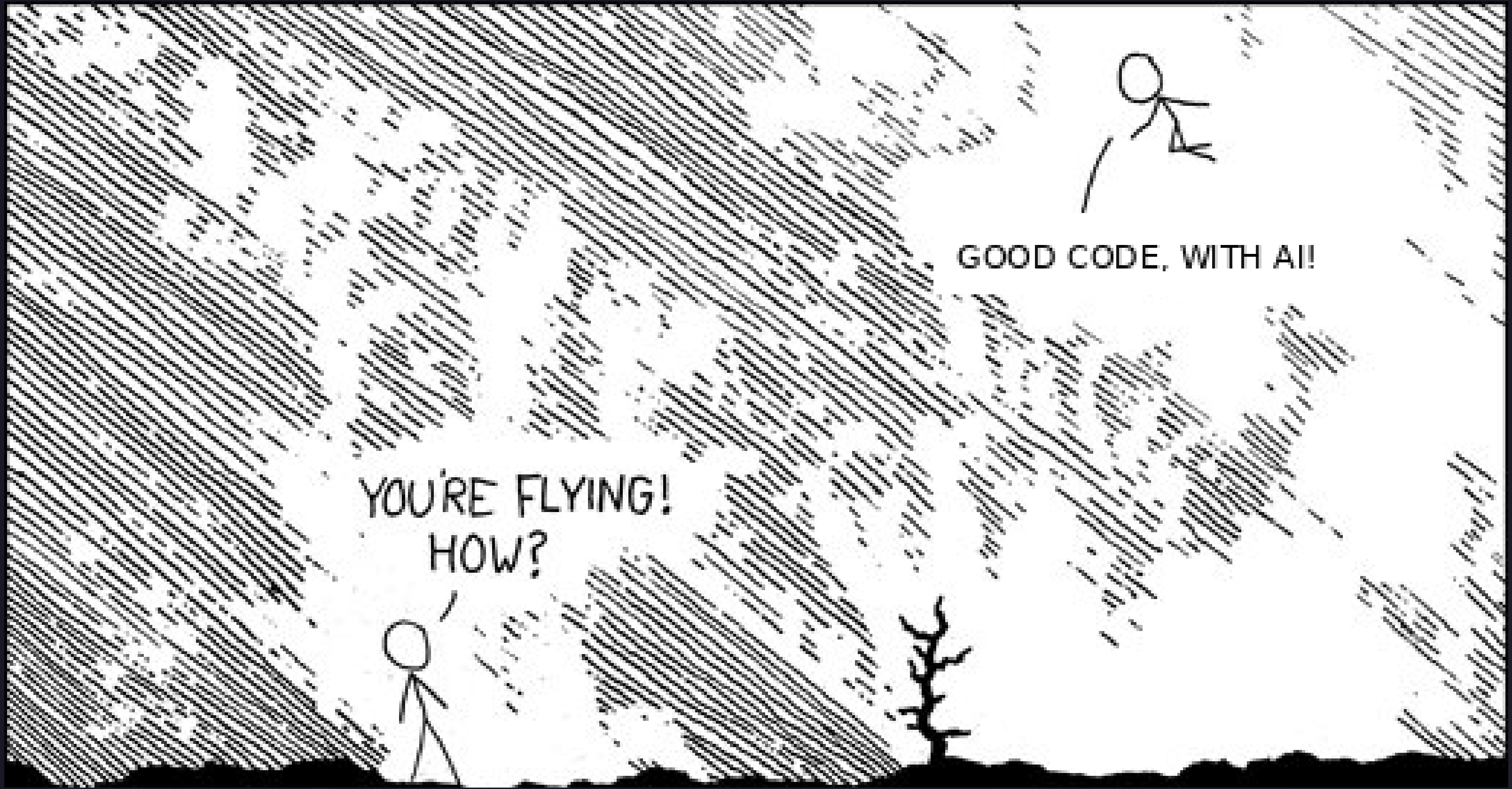
- Free a resource at the same level as it was allocated
- The one who allocates the resource is responsible for freeing it
- Be explicit about assumptions regarding resources

What About AI?

AI

- Disclaimer: we are all newbies
- Similar to working with a weak programmer
- Rarely, it does something extremely stupid
- Even more rarely, it does something truly smart
- The main advantage: it is fast — blazingly fast 🏎️💨
- Using it with good code is fun

Good Code with AI – What Does It Feel Like?



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Take Home Messages

- Use common sense
- KISS, DRY, YAGNI
- Break problems down
- Tell a (simple) story
- Design clean interfaces
- Don't optimize prematurely

Take Home Messages

- Be consistent
- Use formatters and linters
- Assert
- Use TDD
- Refactor