Dealing with the Second Hardest Thing in Computer Science

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"There are only two hard things in Computer Science: cache invalidation and naming things."

- Phil Karlton

The following advice on naming applies to all kinds of programming entities (variables, functions, packages, classes, etc.) and is language-agnostic.

Principle: **Names are a form of abstraction**

> "[T]he best names are those that focus attention on what is most important about the underlying entity while omitting details that are less important."
>
> - John Ousterhout

Importance: **Names are at the core of software design**

If you can't find a name that provides the right abstraction for the underlying entity, it is possible that the underlying entity doesn't have a clear design.

Properties: **Good names are precise and consistent**

If a name is good, it is difficult to miss out on critical information about the entity or to misinterpret the underlying representation.

"The beginning of wisdom is to call things by their proper name."

- Confucius

Good names are a form of documentation.

How good a name is can be assessed by how detailed the accompanying comments need to be.

For example, this has neither good function nor parameter name, and you can tell that from how much work the comments are doing:

```
// function to convert temperature from Fahrenheit to Celsius scale
// temp is the temperature in Fahrenheit
double unitConverter(double temp)
```

Contrast it with:

```
double fahrenheitToCelsius(double tempFahrenheit)
```

We didn't even need a comment here!

Good names rarely require readers to read the documentation to understand what they represent.

Generic names should be avoided.

Generic names don't provide much information about the values or the purpose of the entity they represent.

For example,

```
# generic
count
distance()
size
```

```
# more informative
character_count
euclidean_distance()
memoryBytes
```

Generic names compromise code readability because they provide little information.

Conventions should be followed for generic names.

Sometimes using generic names can improve code readability. But, in such cases, it is **vital** to follow language or domain customs.

For example, using `j` for outermost and `i` for nested loop is confusing!.

```
  for (let j = 0; j < arr.length; j++) {
    for (let i = 0; i < arr[j].length; i++) {
```

In a similar vein,

- `tmp` shouldn't be used to store objects that are not temporary
- `retVal` shouldn't be used for objects not returned from function
- etc.

Don't violate reader assumptions about what generic names represent.

But, seriously, avoid generic names.

If a loop is longer than a few lines, use more meaningful loop variable names than `i`, `j`, `k` because you will quickly lose track of what refers to what.

```
# abstruse
exam_score[i][j]
```

```
# crystal clear
exam_score[school][student]
```

All variables are temporary in some sense. Calling one `tmp` is inviting developers to treat it carelessly and introduce bugs.

```
# generic name
if (right < left) {
  tmp   <- right
  right <- left
  left  <- tmp
}
```

```
# more descriptive
if (right < left) {
 old_right <- right
 right     <- left
 left      <- old_right
}
```

Even when you *think* you need generic names, you are better off using descriptive names.

Names should be consistent.

Consistent names **reduce cognitive burden** for the reader because if they encounter a name in one context, they can safely reuse that knowledge in another context.

For example, these names are inconsistent since the reader can't safely assume the name `size` means the same thing throughout the program.

```
// context-1: `size` stands for number of memory bytes
{
  size = sizeof(x);
}

// context-2: `size` stands for number of elements
{
  size = strlen(a);
}
```

Allow users to make safe assumptions about what the names represent across different scopes/contexts.

Unnecessary words from names should be removed…

```
# okay
convert_to_string()
fileObject
strName # Hungarian notation
```

```
# better
to_string()
file
name
```

but important details should be kept!

```
# okay
child_height
password
id
address
```

```
# better
child_height_cm
plaintext_password
hex_id
ip_address
```

If some information is critical to know, it should be part of the name.

Names should be precise but not *too* long.

How precise (and thus long) the name should be is a **subjective decision**, but keep in mind that long names can obscure visual structure of a program.

You can typically find a middle ground between too short and too long names.

```
# not ideal - too imprecise
d
# okay - can use more precision
days

# good - middle ground
days_since_last_accident

# not ideal - unnecessarily precise
days_since_last_accident_floor_4_lab_23

...
```

Don't go too far with making names precise.

Names should be difficult to misinterpret.

Try your best to misinterpret candidate names and see if you succeed.

E.g., here is a GUI text editor class method to get position of a character:

```cpp
std::tuple<int, int> getCharPosition(int x, int y)
```

How I interpret the parameters `x` and `y`:

> "`x` and `y` refer to pixel positions for a character."

How they are meant to be interpreted:

> "`x` and `y` refer to line of text and character position in that line."

You can avoid such misinterpretation with better names:

```cpp
std::tuple<int, int> getCharPosition(int lineIndex, int charIndex)
```

Precise and unambiguous names leave little room for misconstrual.

Names should be easily searchable.

While naming things, always ask yourself how easy it would be to replace the chosen name with a different name.

E.g., this plotting function uses identifier `p` to represent a scatter plot object.

```r
plotScatter <- function() {
  p <- ggplot(mtcars, aes(wt, mpg)) + geom_point()
  p <- p + labs(title = "my first scatter plot")
  p
}
```

In the future, it won't be easy either to search for and/or to rename it in the code base because searching for `p` would flag all *p*s (e.g. gg**p**lot), and not just the one corresponding to the plot object.

Instead, if `scatter_plot` identifier is used, both search and replace operations will be a piece of cake.

Choose names that can be searched and, if the need arises, replaced.

Names should honor the culture.

The names should respect the conventions adopted in a given project, organization, programming language, domain of knowledge, etc.

For example, C++ convention is to use PascalCase for class names and lowerCamel case for variables.

```cpp
// non-conventional
class playerEntity
{
public:
    std::string HairColor;
};
```

```cpp
// conventional
class PlayerEntity
{
public:
    std::string hairColor;
};
```

Don't break conventions unless other guidelines require overriding them for consistency.

Name Booleans with extra care.

Names for Boolean variables or functions should make clear what true and false means. This can be done using prefixes (**is**, **has**, **can**, etc.).

```
# not great
if (child) {
  if (parentSupervision) {
    watchHorrorMovie <- TRUE
  }
}
```

```
# better
if (isChild) {
  if (hasParentSupervision) {
    canWatchHorrorMovie <- TRUE
  }
}
```

Use positive terms for Booleans since they are easier to process.

```
# double negation - difficult
is_firewall_disabled = FALSE
```

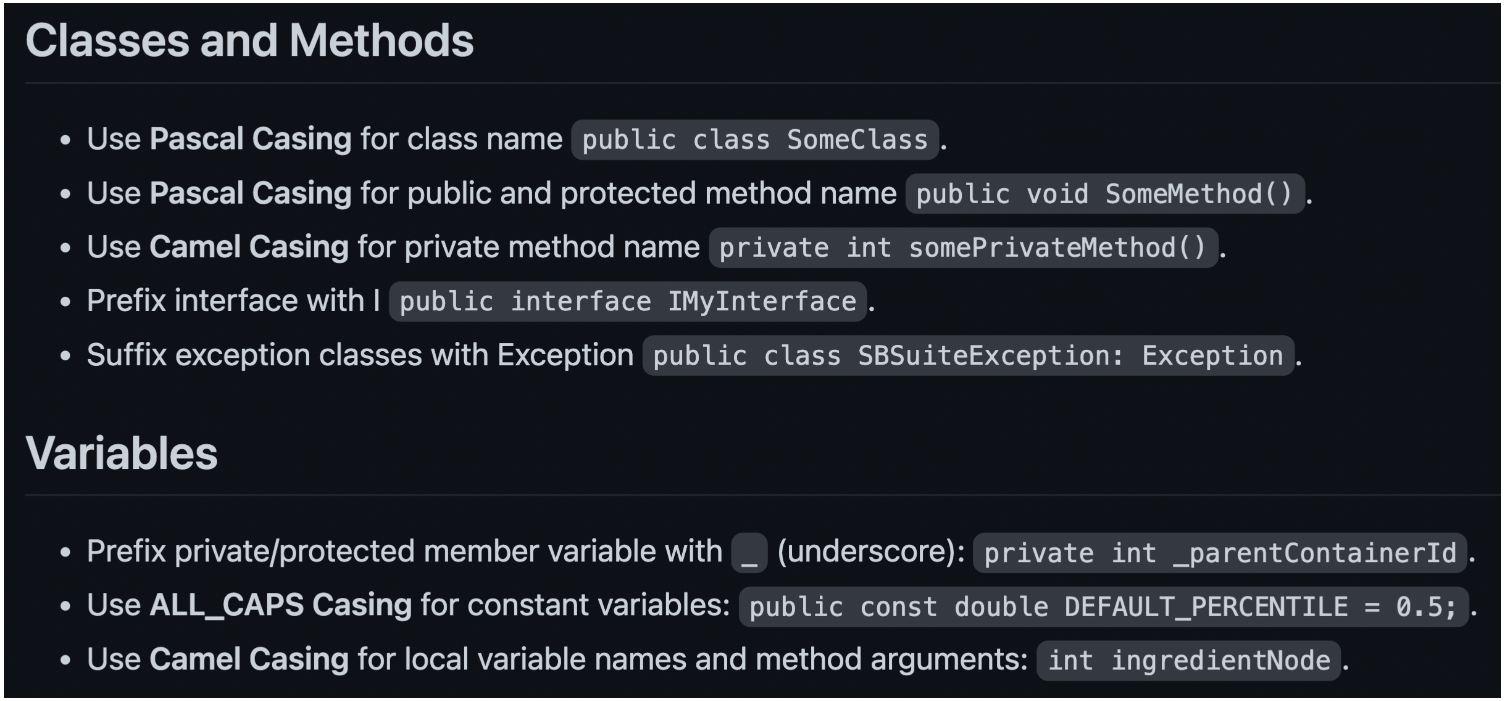
```
# better
is_firewall_enabled = TRUE
```

Give Boolean variable names that convey what true or false implies.

Formatting names can provide additional information.

Having different name formats for different entities makes it easier to read code because it **acts like syntax highlighting**.

Here is an example of formatting conventions (adopted in OSP organization):



Classes and Methods

- Use **Pascal Casing** for class name `public class SomeClass`.
- Use **Pascal Casing** for public and protected method name `public void SomeMethod()`.
- Use **Camel Casing** for private method name `private int somePrivateMethod()`.
- Prefix interface with I `public interface IMyInterface`.
- Suffix exception classes with Exception `public class SBSuiteException: Exception`.

Variables

- Prefix private/protected member variable with `_` (underscore): `private int _parentContainerId`.
- Use **ALL_CAPS Casing** for constant variables: `public const double DEFAULT_PERCENTILE = 0.5;`.
- Use **Camel Casing** for local variable names and method arguments: `int ingredientNode`.

Names should be kept up-to-date.

To resist software entropy, not only should you name entities properly, but you should also rename them to keep up with the new developments.

Otherwise, names will become something worse than meaningless or confusing: **misleading**.

For example, let's say your class has `$getMeans()` method.

- In its initial implementation, it used to return *precomputed* mean values.
- In its current implementation, it *computes* the mean values on the fly.

Therefore, it is misleading to continue to call it a getter method, and it should be renamed to (e.g.) `$computeMeans()`.

Keep an eye out for API changes that make names misleading.

Names should be pronounceable.

This is probably the weakest of the requirements, but one can't deny the ease of communication when names are pronounceable.

If you are writing a function to generate a time-stamp, discussing the following function verbally would be challenging.

```
# generate year month date hour minute second
genymdhms()
```

This is a much better (and pronounceable) alternative:

```
generateTimeStamp()
```

Additionally, avoid naming separate entities with homonyms.

Discussing entities named `waste` and `waist` is inevitably going to lead to confusion.

Use consistent lexicon in a project.

Once you settle down on a mapping from an abstraction to a name, use it consistently *throughout the code base*.

E.g., two similar methods here have different names across `R6` classes:

```
CreditCardAccount$new()$retrieve_expenditure()
DebitCardAccount$new()$fetch_expenditure()
```

Both of these methods should either be named `$retrieve_expenditure()` or `$fetch_expenditure()`.

Consistency of naming conventions should be respected at the code base level, not just for short scopes.

A sundry of don'ts

You won't have to remember any of the following rules if you adopt a single principle:

"Names should be readable for the *reader*, and not *writer*, of code."

Avoid the following (Part-1):

- **Don't use pop-culture references in names.** Not everyone can be expected to be familiar with them. E.g. `female_birdsong_recording` is a better variable name than `thats_what_she_said`.
- **Don't use slang.** You can't assume current or future developers to be familiar with them. E.g. `exit()` is better than `hit_the_road()`.
- **Avoid unintended meanings.** Do your due diligence to check dictionaries (especially Urban dictionary!) if the word has unintended meaning. E.g. `cumulative_sum()` is a better function name than `cumsum()`.
- **Avoid imprecise opposites**, since they can be confusing. E.g. parameter combination `begin`/`last` is worse than either `begin`/end or `first`/`last`.
- **Don't use inconsistent abbreviations.** E.g. instead of using `numColumns` (*number* of columns) in one function and `noRows` (*number* of rows) in another, choose one abbreviation as a prefix and use it consistently.
- **Don't use hard-to-distinguish character pairs in names** (e.g., `l` and `I`, `O` and `0`, etc.). With certain fonts, it can be hard to distinguish `firstl` from `firstI`.

Avoid the following (Part-2):

- **Don't misspell to save a few characters.** Remembering spelling is difficult, and remembering *correct misspelling* even more so. E.g. don't use `hilite` instead of `highlight`. Benefit is not worth the cost here.
- **Don't use commonly misspelled words in English.** Using such names for variables can, at minimum, slow you down, or, at worst, increase the possibility of making an error. E.g. is it `accumulate`, `accummulate`, `acumulate`, or `acummulate`?!
- **Don't use misleading abbreviations.** E.g., in R, `na.rm` parameter removes (`rm`) missing values (`NA`). Using it to mean "remove (`rm`) non-authorized (`NA`) entries" for a function parameter will be misleading.
- **Don't allow multiple English standards.** E.g. using both American and British English standards would've you constantly guessing if the variable is named (e.g.) `centre` or `center`. Adopt one standard and stick to it.
- **Don't use similar names for entities with different meanings.** E.g. `patientRecs` and `patientReps` are easily confused because they are so similar. There should be at least two-letter difference: `patientRecords` and `patientReports`.

Case studies

Looking at names in the wild that violate presented guidelines.

This is **not** to be taken as criticisms but as real-life learning opportunities to drive home the importance of these guidelines.

Violation: Breaking (domain) conventions

R is a programming language for statistical computing, and function names can be expected to respect the domain conventions.

Statistical distributions can be characterized by centrality measures, like mean, median, mode, etc., and R has functions with names that wouldn't surprise you, **except one**:

```r
x <- c(1, 2, 3, 4)
mean(x)   # expected output
median(x) # expected output
mode(x)   # unexpected output!
```

The `mode()` function actually returns the storage mode of an R object!

This function could have been named (e.g.) `storageMode()`, which is more precise and doesn't break domain-specific expectations.

Violation: Generic name

The parameter `N` in `std::array` definition is too generic.

```
template<
    class T,
    std::size_t N
> struct array;
```

`size` is a bit better but still leaves room for misunderstanding:

> "Does it mean length or memory bytes?"

Here is an alternative parameter name:

```
template<
    class T,
    std::size_t numberOfElements
> struct array;
```

`numberOfElements` is more precise and unmistakable

Violation: Inconsistency in naming schema

ggplot2 is a plotting framework in R.

Admirably, it supports both **British** and **American** English spelling standards.

But does it do so *consistently*?

Function names

Both forms of spellings are supported.

```
# works
guide_colorbar(...)

# this works as well!
guide_colourbar(...)
```

Function parameters

Both forms of spellings are supported.

```
# works
aes(color = ...)

# this works as well!
aes(colour = ...)
```

Function names *and* parameters

A user has now come to believe that *ggplot2* supports British and American spellings for both function names *and* parameters.

And, since they prefer American spellings, they do this:

```
guide_colorbar(ticks.color = "black")
```

That won't work!

Both functions support **only** the British spelling of parameters:

```
guide_colourbar(ticks.colour = "black")
guide_colorbar(ticks.colour = "black")
```

This is **inconsistent** and **violates user's mental model** about function and parameter naming schema*.

*This can also be a painful source of bugs because the function will fail silently.

Violation: Room for misunderstanding

In Python, `filter()` can be used to apply a function to an iterable.

```
list(filter(lambda x: x > 0, [-1, 1]))
```

But `filter` is an ambiguous word:

- It could mean to pick out elements that pass a condition (what *remains after filtering*), or
- it could mean to pick out elements that need to be removed (what *is filtered*).

Imagine you've never used this function before. Can you predict if it will return `1` or `-1`?

It returns `1`, so the intent is to pick out the elements that pass the condition. In this case, **`keep()`** would've be a better name.

Had the intent been to find elements to remove, **`discard()`** would've be a better name.

etc.

It is easy to find such violations, but, whenever you encounter one, make it a personal exercise to come up with a better name.

Challenges

Worth the struggle

Initially, you may struggle to find good names and settle down for the first serviceable name that pops into your head.

Resist the urge!

Adopt an investment mindset and remember that the little extra time invested in finding good names early on will pay dividends in the long run by reducing accumulation of complexity in the system.

The more you do it, the easier it will get!

And, after a while, you won't even need to think long and hard to come up with a good name. You will instinctively think of one!

Benefits of naming things well

"What's in a name?" Well, everthing!

- Intent-revealing names make the **code easier to read**.
- Trying to find good names forces you to detach from the problem-solving mindset and to **focus on the bigger picture** that motivates this change. This is critical for thoughtful software design.
- Searching for precise names requires clarity, and seeking such clarity **improves your own understanding** of the code.
- Naming precisely and consistently **reduces ambiguities and misunderstandings**, which in turn reduces the possibility of bugs.
- Good names **reduce the need for documentation**.
- Consistent naming **reduces cognitive overload** for the developers and make the code more readable and maintainable.
- etc.

Further Reading

For a more detailed discussion about how to name things, check out following references. The **page numbers** in parentheses point to relevant sections/chapters.

- McConnell, S. (2004). *Code Complete*. Microsoft Press. (**pp. 259-290**)
- Boswell, D., & Foucher, T. (2011). *The Art of Readable Code*. O'Reilly Media, Inc. (**pp. 7-31**)
- Ousterhout, J. K. (2018). *A Philosophy of Software Design*. Palo Alto: Yaknyam Press. (**pp. 121-129**)
- Martin, R. C. (2009). *Clean Code*. Pearson Education.(**pp. 17-30**)
- Thomas, D., & Hunt, A. (2019). *The Pragmatic Programmer*. Addison-Wesley Professional. (**pp. 238-242**)

For a good example of organizational naming guidelines, see:

- Google C++ Style Guide

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The End 👋