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 design isn't clear.

i 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 misunderstand what it represents.

"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 comment needs to be.

E.g., the function and parameter are named poorly here, and so comments need to do all the heavy lifting:

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

Contrast it with this:

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

No need for a comment here!



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

Generic names should follow conventions

Using generic names can improve code readability, but *only if* language or domain customs are followed.

Examples:

• In a nested loop, using j for outer and i for inner loop index is confusing!

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

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



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

Alternatives to generic names

If a loop is longer than a few lines, use more meaningful loop variable names than \pm , \pm , and k because you will quickly lose track of what they mean.

```
# abstruse
                                                            # crystal clear
                                                          2 exam_score[school][student]
2 exam_score[i][j]
```

All variables are temporary in some sense. Calling one tmp is inviting carelessness.

```
# generic name
2 if (right < left) {</pre>
  tmp = right
   right = left
   left = tmp
6 }
```

```
# more descriptive
2 if (right < left) {</pre>
    old_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** because if the reader encounters 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 that the name *size* means the same thing throughout the program.

```
1 // context-1: `size` stands for number of memory bytes
2 {
3    size = sizeof(x);
4 }
5
6 // context-2: `size` stands for number of elements
7 {
8    size = strlen(a);
9 }
```

```
1 // context-1:
2 {
3    size = sizeof(x);
4 }
5
6 // context-2:
7 {
8    length = strlen(a);
9 }
```



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

Unnecessary details in names should be removed...

```
1 # okay
2 convert_to_string()
3 fileObject
4 strName # Hungarian notation

1 # better
2 to_string()
3 file
4 name
```

i Avoid redundancy

- In type names, avoid using class, data, object, and type (e.g. bad: classShape, good: Shape)
- In function names, avoid using be, do, perform, etc. (e.g. bad: doAddition(), good: add())

but important details should be kept!

```
1 # okay
2 child_height
3 password
4 id
5 address

1 # better
2 child_height_cm
3 plaintext_password
4 hex_id
5 ip_address
```



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

Names should utilize the context

When naming, avoid redundant words by exploiting the context.

E.g. if you are defining a class, its methods and variables will be read in that context.

```
# okay
                                                              # better
 Router.run router()
                                                              Router.run()
  FileHandler.close file()
                                                              FileHandler.close()
4 BeerShelf.beer count
                                                              BeerShelf.count
```

But, if doing so imposes ambiguity, then you can of course tolerate some redundancy.

```
1 # bad
                                                             # better
2 MediaPlaver.plav()
                                                          2 MediaPlayer.play_audio()
                                                          3 MediaPlayer.play video()
```



Shorten names with the help of context.

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 the visual structure of a program.

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

```
1 # not ideal - too imprecise
2 d
3
4 # okay - can use more precision
5 days
6
7 # good - middle ground
8 days_since_last_accident
9
10 # not ideal - unnecessarily precise
11 days_since_last_accident_floor_4_lab_23
12
13 ...
```



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:

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

How I interpret: "x and y refer to pixel positions for a character."

In reality: "x and y refer to line of text and character position in that line."

You can avoid such misinterpretation with better names:

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



Precise and unambiguous names leave little room for misconstrual.

Names should be distinguishable

Names that are too similar make great candidates for mistaken identity.

E.g. nn and nnn are easy to be confused and such confusion can lead to painful bugs.

```
1 // bad

2 let n = x;

3 let nn = x ** 2;

4 let nnn = x ** 3;
```



Any pair of names should be difficult to be mistaken for each other.

Names should be searchable

While naming, always ask yourself how easy it would be to find and update the name.

E.g., this function uses a and f parameters to represent an array and a function.

```
arrayMap <- function(a, f) {</pre>
                                                        arrayMap <- function(arr, fun) {</pre>
```

If needed, it wouldn't be easy either to search for and/or to rename these parameters in the codebase because searching for a or f would flag all g and f (api, file, etc.).

Instead, if more descriptive identifiers are used, both search and replace operations will be straightforward. In general, searchability of a name indexes how generic it is.



Choose names that can be searched and, if needed, replaced.

Names should honour the conventions

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.

```
1 // non-conventional
2 class playerEntity
3 {
4  public:
5  std::string HairColor;
6 };
```

```
// 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 mean. This can be done using prefixes (**is**, **has**, **can**, etc.).

```
1 # not great
2 if (child) {
3 if (parentSupervision) {
4 watchHorrorMovie <- TRUE
5 }
6 }</pre>
```

```
1 # better
2 if (isChild) {
3   if (hasParentSupervision) {
4     canWatchHorrorMovie <- TRUE
5   }
6 }</pre>
```

In general, use positive terms for Booleans since they are easier to process.

```
1 # double negation - difficult
2 is_firewall_disabled <- FALSE
```

```
1 # better
2 is_firewall_enabled <- TRUE
```

But if the variable is only ever used in its false version (e.g. is_volcano_inactive), the negative version can be easier to work with.



Boolean variable names should convey what true or false values represent.

Avoid implementation details in names

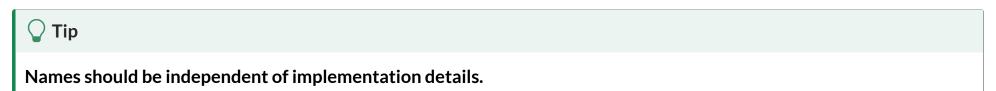
Names with implementation details (e.g., data structure) have high maintenance cost. When implementation changes, identifiers need to change as well.

E.g., consider variables that store data in different data structures or cloud services:

```
1 # bad
2 bonuses_pd # pandas DataFrame
3 bonuses_pl # polars DataFrame
4
5 aws_s3_url # AWS bucket
6 gcp_url # GCP bucket

1 # good
2 bonuses # data structure independent
3
4 bucket_url # cloud service independent
```

Note that good names don't need to change even if the implementation details change.



Find correct abstraction level for names

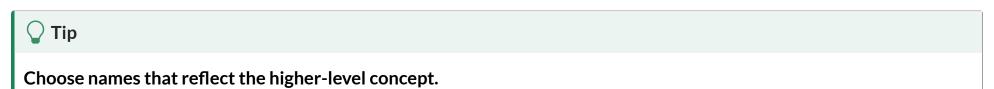
Don't select names at a lower level of abstraction just because that's where the corresponding objects were defined.

E.g., if you are writing a function to compute difference between before and after values, the parameter names should reflect the higher-level concept.

```
1 # bad
2 function(value_before, value_after) { ... }

1 # good
2 function(value1, value2) { ... }
```

Note that the good parameter names clarify the general purpose of the function, which is to compute difference between *any* two values, not just before and after values.



Test function names should be detailed

If unit testing in a given programming language requires writing test functions, choose names that describe the details of the test.

The test function names should effectively act as a comment.

```
1  # bad
2  def test1
3  def my_test
4  def retrieve_commands
5  def serialize_success
```

```
1  # good
2  def test_array
3  def test_multilinear_model
4  def all_the_saved_commands_should_be_retrieved
5  def should_serialize_the_formula_cache_if_required
```

(i) Note

Don't hesitate to choose lengthy names for test functions.

Unlike regular functions, long names are less problematic for test functions because

- they are not visible or accessible to the users
- they are not called repeatedly throughout the codebase

Names should be kept up-to-date

To resist software entropy, not only should you name entities properly, but you should also update them. Otherwise, names will become something worse than meaningless or confusing: **misleading**.

For example, let's say your class has the \$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.

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

This is a much better (and pronounceable) alternative:

```
1 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:

```
1 CreditCardAccount$new()$retrieve_expenditure()
2 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 both narrow and broad scopes.

Choose informative naming conventions

Having different name formats for different entities **acts like syntax highlighting**. That is, a name not only represents an entity but also provides hints about its nature.

- Example of coding standards adopted in OSP organization
 Use all ALL_CAPS for constant variables (public const double PI = 3.14;)
 Prefix private/protected member variable with _ (private int _currentDebt)
 Use Pascal Casing for class names (public class GlobalAccounting)
 Use Pascal Casing for public and protected method name (public void GetRevenues())
 Use Camel Casing for private method name (private int balanceBooks())
 ...
 - **◯** Tip

Following a convention consistently is more important than which convention you adopt.

ICYMI: Available casing conventions

There are various casing conventions used for software development.



Illustration (CC-BY) by Allison Horst

A sundry of don'ts

You won't have to remember any of these rules if you follow the following principle:

"Names must be readable for the reader, not writer, of code."

- 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 hard-to-distinguish character pairs in names (e.g., 1 and 1, 0 and 0, etc.). With certain fonts, it can be hard to distinguish first1 from first1.

- **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 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. The 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, accumulate, accumulate, or acumulate?!
- Don't use numeric suffixes in names to specify levels. E.g. variable names level1, level2, level3 are not as informative as beginner, intermediate, advanced.

- **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 have 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 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, and R has functions with names that wouldn't surprise you, **except one**:

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

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.

```
1 template<
2   class T,
3   std::size_t N
4 > 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:

```
1 template<
2    class T,
3    std::size_t numberOfElements
4 > struct array;
```

numberOfElements is more precise and unmistakable.

Violation: Inconsistency in naming

ggplot2 is a plotting framework in R, and supports both **British** and **American** English spelling standards. But does it do so *consistently*?

Function names

Function parameters

```
1  # works
2  guide_colorbar(...)
3
4  # this works as well!
5  guide_colourbar(...)
1  # works
2  aes(color = ...)
3  4  # this works as well!
5  aes(colour = ...)
```

A user now believes that both spelling standards for function names *and* parameters are supported. And, since they prefer American spellings, they do this:

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

That won't work! Both functions support **only** the British spelling of parameters:

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

This is inconsistent and violates the user's mental model about naming schema.

Violation: Room for misunderstanding

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

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

But filter is an ambiguous word. It could mean either of these:

- to pick out elements that pass a condition (what remains after filtering)
- to pick out elements that need to be removed (what is filtered out)

If you've never used this function before, could you predict if it returns 1 or -1?

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

Had the intent been to find elements to remove, discard() would 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.

Naming and good design

Deep dive into benefits of thoughtful naming for an entity at the heart of all software: **function**

Following Unix philosophy

Unix philosophy specifies the golden rule for writing good a function: "Do One Thing And Do It Well."

Finding a descriptive name for a function can inform us if we are following this rule.

Consider a function to extract a table of regression estimates for a statistical model. For convenience, it also allows sorting the table by estimate.



```
Naming is easy

These individual functions are easier to read, understand, and test.

1  extract_estimates <- function(model) {
2    # code to extract estimates from model
3    ...
4  }
5    6  sort_estimates <- function(table, sort = "asc") {
7    # code to sort table
8    ...
9 }</pre>
```

Function parameter names

When it comes to writing a good function, finding a good name for a parameter can also reveal design problems.

E.g. a boolean or flag parameter name means function is doing more than one thing.

Consider a function that converts Markdown or HTML documents to PDF.

```
Boolean parameter name

Doing more than one thing.

1 convert_to_pdf <- function(file, is_markdown = FALSE) {
2 if (is_markdown) {
3 # code to convert Markdown to PDF
4 ...
5 }
6
7 if (!is_markdown) {
8 # code to convert HTML to PDF
9 ...
10 }
11 }
```

```
Non-boolean parameter name

Doing one thing.

1  convert_md_to_pdf <- function(file) {
2  # code to convert Markdown to PDF
3  ...
4  }
5
6  convert_html_to_pdf <- function(file) {
7  # code to convert HTML to PDF
8  ...
9 }</pre>
```

"In your name I will hope, for your name is good."

- Psalms 52:9

Benefits of good names

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

- 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 makes the code more maintainable.

Challenges

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

Resist the urge!

Worth the struggle

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 the 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.

"Using understandable names is a foundational step to producing quality software."

- Al Sweigart

Further Reading

For a more detailed discussion about how to name things, see the following references.

References

- 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)
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- Goodliffe, P. (2007). Code Craft. No Starch Press. (pp. 39-56)
- Padolsey, J. (2020). Clean Code in JavaScript. Packt Publishing. (pp. 93-111)
- Thomas, D., & Hunt, A. (2019). *The Pragmatic Programmer*. Addison-Wesley Professional. (pp. 238-242)
- Ottinger's Rules for Variable and Class Naming
- For a good example of organizational naming guidelines, see Google C++ Style Guide.

For more

If you are interested in good programming and software development practices, check out my other slide decks.

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Thank You

And Happy Naming!

Session information

```
1 sessioninfo::session_info(include_base = TRUE)
- Session info -
setting value
version R version 4.4.2 (2024-10-31)
        Ubuntu 22.04.5 LTS
system x86_64, linux-qnu
hostname fv-az1118-520
ui
        X11
language (EN)
collate C.UTF-8
ctype C.UTF-8
        UTC
tz
        2025-01-05
 date
        3.6.1 @ /opt/hostedtoolcache/pandoc/3.6.1/x64/ (via rmarkdown)
pandoc
        1.7.5 @ /usr/local/bin/quarto
quarto
- Packages -
package
           * version date (UTC) lib source
base * 4.4.2 2024-10-31 [3] local
cli 3.6.3 2024-06-21 [1] RSPM
compiler 4.4.2 2024-10-31 [3] local
```