



API Design Guidelines

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Fundamentals

- **Clarity at the point of use** is your most important goal. Entities such as methods and properties are declared only once but *used* repeatedly. Design APIs to make those uses clear and concise. When evaluating a design, reading a declaration is seldom sufficient; always examine a use case to make sure it looks clear in context.
- **Clarity is more important than brevity.** Although Swift code can be compact, it is a *non-goal* to enable the smallest possible code with the fewest characters. Brevity in Swift code, where it occurs, is a side-effect of the strong type system and features that naturally reduce boilerplate.
- **Write a documentation comment** for every declaration. Insights gained by writing documentation can have a profound impact on your design, so don't put it off.

If you are having trouble describing your API's functionality in simple terms, **you may have designed the wrong API.**

- Use Swift's **dialect of Markdown**.
- **Begin with a summary** that describes the entity being declared. Often, an API can be completely understood from its declaration and its summary.

```
/// Returns a "view" of `self` containing the same elements in  
/// reverse order.  
func reversed() -> ReverseCollection
```

- **Focus on the summary**; it's the most important part. Many excellent documentation comments consist of nothing more than a great summary.
- **Use a single sentence fragment** if possible, ending with a period. Do not use a complete sentence.
- **Describe what a function or method *does* and what it *returns***, omitting null effects and `Void` returns:

```
/// Inserts `newHead` at the beginning of `self`.  
mutating func prepend(_ newHead: Int)  
  
/// Returns a `List` containing `head` followed by the elements  
/// of `self`.  
func prepending(_ head: Element) -> List  
  
/// Removes and returns the first element of `self` if non-empty;  
/// returns `nil` otherwise.  
mutating func popFirst() -> Element?
```

Note: in rare cases like `popFirst` above, the summary is formed of multiple sentence fragments separated by semicolons.

- **Describe what a subscript *accesses***:

```
/// Accesses the `index`th element.  
subscript(index: Int) -> Element { get set }
```

- **Describe what an initializer *creates***:

```
/// Creates an instance containing `n` repetitions of `x`.  
init(count n: Int, repeatedElement x: Element)
```

- For all other declarations, **describe what the declared entity is**.

```

/// A collection that supports equally efficient insertion/removal
/// at any position.
struct List {

    /// The element at the beginning of `self`, or `nil` if self
    /// empty.
    var first: Element?
    ...

```

- **Optionally, continue** with one or more paragraphs and bullet items.

Paragraphs are separated by blank lines and use complete sentences.

```

/// Writes the textual representation of each      ← Summary
/// element of `items` to the standard output.
///
/// The textual representation for each item `x`    ← Blank line
/// is generated by the expression `String(x)`.     ← Additional discussion
///
/// - Parameter separator: text to be printed
///   between items.
/// - Parameter terminator: text to be printed
///   at the end.
///
/// - Note: To print without a trailing
///   newline, pass `terminator: ""`
///
/// - SeeAlso: `CustomDebugStringConvertible`,
///   `CustomStringConvertible`, `debugPrint`.
public func print(
    _ items: Any..., separator: String = " ", terminator: String = "\n

```

Parameters section

Symbol commands

- Use recognized **symbol documentation markup** elements to add information beyond the summary, whenever appropriate.
- Know and use recognized bullet items with **symbol command syntax**. Popular development tools such as Xcode give special treatment to bullet items that start with the following keywords:

<u>Attention</u>	<u>Author</u>	<u>Authors</u>	<u>Bug</u>
<u>Complexity</u>	<u>Copyright</u>	<u>Date</u>	<u>Experiment</u>
<u>Important</u>	<u>Invariant</u>	<u>Note</u>	<u>Parameter</u>
<u>Parameters</u>	<u>Postcondition</u>	<u>Precondition</u>	<u>Remark</u>
<u>Requires</u>	<u>Returns</u>	<u>SeeAlso</u>	<u>Since</u>
<u>Throws</u>	<u>Todo</u>	<u>Version</u>	<u>Warning</u>

Naming

Promote Clear Usage

- **Include all the words needed to avoid ambiguity** for a person reading code where the name is used.

For example, consider a method that removes the element at a given position within a collection.

```
extension List {
  public mutating func remove(at position: Index) -> Element
}
employees.remove(at: x)
```

If we were to omit the word `at` from the method signature, it could imply to the reader that the method searches for and removes an element equal to `x`, rather than using `x` to indicate the position of the element to remove.

```
employees.remove(x) // unclear: are we removing x?
```

- **Omit needless words.** Every word in a name should convey salient information at the use site.

More words may be needed to clarify intent or disambiguate meaning, but those that are redundant with information the reader already possesses should be omitted. In particular, omit words that *merely repeat* type information.

```
public mutating func removeElement(_ member: Element) -> Element?

allViews.removeElement(cancelButton)
```

In this case, the word `Element` adds nothing salient at the call site. This API would be better:

```
public mutating func remove(_ member: Element) -> Element?

allViews.remove(cancelButton) // clearer
```

Occasionally, repeating type information is necessary to avoid ambiguity, but in general it is better to use a word that describes a parameter's *role* rather than its type. See the next item for details.

- **Name variables, parameters, and associated types according to their roles,** rather than their type constraints.

```
var string = "Hello"
protocol ViewController {
    associatedtype ViewType : View
}
class ProductionLine {
    func restock(from widgetFactory: WidgetFactory)
}
```

Repurposing a type name in this way fails to optimize clarity and expressivity. Instead, strive to choose a name that expresses the entity's *role*.

```
var greeting = "Hello"
protocol ViewController {
    associatedtype ContentView : View
}
class ProductionLine {
    func restock(from supplier: WidgetFactory)
}
```

If an associated type is so tightly bound to its protocol constraint that the protocol name *is* the role, avoid collision by appending `Type` to the associated type name:

```
protocol Sequence {
    associatedtype IteratorType : Iterator
}
```

- **Compensate for weak type information** to clarify a parameter's role.

Especially when a parameter type is `NSObject`, `Any`, `AnyObject`, or a fundamental type such `Int` or `String`, type information and context at the point of use may not fully convey intent. In this example, the declaration may be clear, but the use site is vague.

```
func add(_ observer: NSObject, for keyPath: String)
grid.add(self, for: graphics) // vague
```

To restore clarity, **precede each weakly typed parameter with a noun describing its role**:

```
func addObserver(_ observer: NSObject, forKeyPath path: String)
grid.addObserver(self, forKeyPath: graphics) // clear
```

Strive for Fluent Usage

- **Prefer method and function names that make use sites form grammatical English phrases.**

<code>x.insert(y, at: z)</code>	"x, insert y at z"
<code>x.subViews(havingColor: y)</code>	"x's subviews having color y"
<code>x.capitalizingNouns()</code>	"x, capitalizing nouns"

```
x.insert(y, position: z)
x.subViews(color: y)
x.nounCapitalize()
```

It is acceptable for fluency to degrade after the first argument or two when those arguments are not central to the call's meaning:

```
AudioUnit.instantiate(
  with: description,
  options: [.inProcess], completionHandler: stopProgressBar)
```

- **Begin names of factory methods with "make"**, e.g. `x.makeIterator()`.
- **Initializer and factory method calls** should form a phrase that does not include the first argument, e.g. `x.makeWidget(cogCount: 47)`

For example, the phrases implied by these calls do not include the first argument:

```
let foreground = Color(red: 32, green: 64, blue: 128)
let newPart = factory.makeWidget(gears: 42, spindles: 14)
```

In the following, the API author has tried to create grammatical continuity with the first argument.

```
let foreground = Color(havingRGBValuesRed: 32, green: 64, andBlue: 128)
let newPart = factory.makeWidget(havingGearCount: 42, andSpindleCount: 14
```

In practice, this guideline along with those for argument labels means the first argument will have a label unless the call is performing a value preserving type conversion.

```
let rgbForeground = RGBColor(cmykForeground)
```

• **Name functions and methods according to their side-effects**

- Those without side-effects should read as noun phrases, e.g.
`x.distance(to: y)` , `i.successor()` .
- Those with side-effects should read as imperative verb phrases, e.g.,
`print(x)` , `x.sort()` , `x.append(y)` .
- **Name Mutating/nonmutating method pairs** consistently. A mutating method will often have a nonmutating variant with similar semantics, but that returns a new value rather than updating an instance in-place.
 - When the operation is **naturally described by a verb**, use the verb's imperative for the mutating method and apply the “ed” or “ing” suffix to name its nonmutating counterpart.

Mutating	Nonmutating
<code>x.sort()</code>	<code>z = x.sorted()</code>
<code>x.append(y)</code>	<code>z = x.appending(y)</code>

- Prefer to name the nonmutating variant using the verb's past participle (usually appending “ed”):

```

/// Reverses `self` in-place.
mutating func reverse()

/// Returns a reversed copy of `self`.
func reversed() -> Self
...
x.reverse()
let y = x.reversed()

```

- When adding “ed” is not grammatical because the verb has a direct object, name the nonmutating variant using the verb’s present participle, by appending “ing.”

```

/// Strips all the newlines from `self`
mutating func stripNewlines()

/// Returns a copy of `self` with all the newlines stripped
func strippingNewlines() -> String
...
s.stripNewlines()
let oneLine = t.strippingNewlines()

```

- When the operation is **naturally described by a noun**, use the noun for the nonmutating method and apply the “form” prefix to name its mutating counterpart.

Nonmutating	Mutating
<code>x = y.union(z)</code>	<code>y.formUnion(z)</code>
<code>j = c.successor(i)</code>	<code>c.formSuccessor(&i)</code>

- **Uses of Boolean methods and properties should read as assertions about the receiver** when the use is nonmutating, e.g. `x.isEmpty` , `line1.intersects(line2)` .
- **Protocols that describe *what something is* should read as nouns** (e.g. `Collection`).
- **Protocols that describe a *capability* should be named using the suffixes *able*, *ible*, or *ing*** (e.g. `Equatable` , `ProgressReporting`).
- The names of other **types, properties, variables, and constants should read as nouns**.

Use Terminology Well

Term of Art *noun* - a word or phrase that has a precise, specialized meaning within a particular field or profession.

- **Avoid obscure terms** if a more common word conveys meaning just as well. Don't say "epidermis" if "skin" will serve your purpose. Terms of art are an essential communication tool, but should only be used to capture crucial meaning that would otherwise be lost.
- **Stick to the established meaning** if you do use a term of art.

The only reason to use a technical term rather than a more common word is that it *precisely* expresses something that would otherwise be ambiguous or unclear. Therefore, an API should use the term strictly in accordance with its accepted meaning.

- **Don't surprise an expert:** anyone already familiar with the term will be surprised and probably angered if we appear to have invented a new meaning for it.
- **Don't confuse a beginner:** anyone trying to learn the term is likely to do a web search and find its traditional meaning.
- **Avoid abbreviations.** Abbreviations, especially non-standard ones, are effectively terms-of-art, because understanding depends on correctly translating them into their non-abbreviated forms.

The intended meaning for any abbreviation you use should be easily found by a web search.

- **Embrace precedent.** Don't optimize terms for the total beginner at the expense of conformance to existing culture.

It is better to name a contiguous data structure `Array` than to use a simplified term such as `List`, even though a beginner might grasp the meaning of `List` more easily. Arrays are fundamental in modern computing, so every programmer knows—or will soon learn—what an array is. Use a term that most programmers are familiar with, and their web searches and questions will be rewarded.

Within a particular programming *domain*, such as mathematics, a widely precededented term such as `sin(x)` is preferable to an explanatory phrase such as `verticalPositionOnUnitCircleAtOriginOfEndOfRadiusWithAngle(x)`. Note that in this case, precedent outweighs the guideline to avoid abbreviations: although the complete word is `sine`, “sin(x)” has been in common use among programmers for decades, and among mathematicians for centuries.

Conventions

General Conventions

- **Document the complexity of any computed property that is not $O(1)$.** People often assume that property access involves no significant computation, because they have stored properties as a mental model. Be sure to alert them when that assumption may be violated.
- **Prefer methods and properties to free functions.** Free functions are used only in special cases:

1. When there's no obvious `self`:

```
min(x, y, z)
```

2. When the function is an unconstrained generic:

```
print(x)
```

3. When function syntax is part of the established domain notation:

```
sin(x)
```

- **Follow case conventions.** Names of types and protocols are `UpperCamelCase`. Everything else is `lowerCamelCase`.

Acronyms and initialisms that commonly appear as all upper case in American English should be uniformly up- or down-cased according to case conventions:

```
var utf8Bytes: [UTF8.CodeUnit]
var isRepresentableAsASCII = true
var userSMTPServer: SecureSMTPServer
```

Other acronyms should be treated as ordinary words:

```
var radarDetector: RadarScanner  
var enjoysScubaDiving = true
```

- **Methods can share a base name** when they share the same basic meaning or when they operate in distinct domains.

For example, the following is encouraged, since the methods do essentially the same things:

```
extension Shape {  
  /// Returns `true` iff `other` is within the area of `self`.  
  func contains(_ other: Point) -> Bool { ... }  
  
  /// Returns `true` iff `other` is entirely within the area of `self`.  
  func contains(_ other: Shape) -> Bool { ... }  
  
  /// Returns `true` iff `other` is within the area of `self`.  
  func contains(_ other: LineSegment) -> Bool { ... }  
}
```

And since geometric types and collections are separate domains, this is also fine in the same program:

```
extension Collection where Element : Equatable {  
  /// Returns `true` iff `self` contains an element equal to  
  /// `sought`.  
  func contains(_ sought: Element) -> Bool { ... }  
}
```

However, these `index` methods have different semantics, and should have been named differently:

```
extension Database {  
  /// Rebuilds the database's search index  
  func index() { ... }  
  
  /// Returns the `n`th row in the given table.  
  func index(_ n: Int, inTable: TableID) -> TableRow { ... }  
}
```

Lastly, avoid “overloading on return type” because it causes ambiguities in the presence of type inference.

```
extension Box {
  /// Returns the `Int` stored in `self`, if any, and
  /// `nil` otherwise.
  func value() -> Int? { ... }

  /// Returns the `String` stored in `self`, if any, and
  /// `nil` otherwise.
  func value() -> String? { ... }
}
```

Parameters

```
func move(from start: Point, to end: Point)
```

- **Choose parameter names to serve documentation.** Even though parameter names do not appear at a function or method's point of use, they play an important explanatory role.

Choose these names to make documentation easy to read. For example, these names make documentation read naturally:

```
/// Return an `Array` containing the elements of `self`
/// that satisfy `predicate`.
func filter(_ predicate: (Element) -> Bool) -> [Generator.Element]

/// Replace the given `subRange` of elements with `newElements`.
mutating func replaceRange(_ subRange: Range, with newElements: [E])
```

These, however, make the documentation awkward and ungrammatical:

```
/// Return an `Array` containing the elements of `self`
/// that satisfy `includedInResult`.
func filter(_ includedInResult: (Element) -> Bool) -> [Generator.Element]

/// Replace the range of elements indicated by `r` with
/// the contents of `with`.
mutating func replaceRange(_ r: Range, with: [E])
```

- **Take advantage of defaulted parameters** when it simplifies common uses. Any parameter with a single commonly-used value is a candidate for a default.

Default arguments improve readability by hiding irrelevant information. For example:

```
let order = lastName.compare(
  royalFamilyName, options: [], range: nil, locale: nil)
```

can become the much simpler:

```
let order = lastName.compare(royalFamilyName)
```

Default arguments are generally preferable to the use of method families, because they impose a lower cognitive burden on anyone trying to understand the API.

```
extension String {  
  /// ...description...  
  public func compare(  
    _ other: String, options: CompareOptions = [],  
    range: Range? = nil, locale: Locale? = nil  
  ) -> Ordering  
}
```

The above may not be simple, but it is much simpler than:

```
extension String {  
  /// ...description 1...  
  public func compare(_ other: String) -> Ordering  
  /// ...description 2...  
  public func compare(_ other: String, options: CompareOptions) -> Ordering  
  /// ...description 3...  
  public func compare(  
    _ other: String, options: CompareOptions, range: Range) -> Ordering  
  /// ...description 4...  
  public func compare(  
    _ other: String, options: StringCompareOptions,  
    range: Range, locale: Locale) -> Ordering  
}
```

Every member of a method family needs to be separately documented and understood by users. To decide among them, a user needs to understand all of them, and occasional surprising relationships—for example, `foo(bar: nil)` and `foo()` aren't always synonyms—make this a tedious process of ferreting out minor differences in mostly identical documentation. Using a single method with defaults provides a vastly superior programmer experience.

- **Prefer to locate parameters with defaults toward the end** of the parameter list. Parameters without defaults are usually more essential to the semantics of a method, and provide a stable initial pattern of use where methods are invoked.

Argument Labels

```
func move(from start: Point, to end: Point)  
x.move(from: x, to: y)
```

- **Omit all labels when arguments can't be usefully distinguished**, e.g.
`min(number1, number2)`, `zip(sequence1, sequence2)`.

- In initializers that perform value preserving type conversions, omit the first argument label, e.g. `Int64(someUInt32)`

The first argument should always be the source of the conversion.

```
extension String {
  // Convert `x` into its textual representation in the given radix
  init(_ x: BigInt, radix: Int = 10) ← Note the initial underscore
}

text = "The value is: "
text += String(veryLargeNumber)
text += " and in hexadecimal, it's"
text += String(veryLargeNumber, radix: 16)
```

In “narrowing” type conversions, though, a label that describes the narrowing is recommended.

```
extension UInt32 {
  /// Creates an instance having the specified `value`.
  init(_ value: Int16) ← Widening, so no label
  /// Creates an instance having the lowest 32 bits of `source`.
  init(truncating source: UInt64)
  /// Creates an instance having the nearest representable
  /// approximation of `valueToApproximate`.
  init(saturating valueToApproximate: UInt64)
}
```

A value preserving type conversion is a monomorphism, i.e. every difference in the value of the source results in a difference in the value of the result. For example, conversion from `Int8` to `Int64` is value preserving because every distinct `Int8` value is converted to a distinct `Int64` value. Conversion in the other direction, however, cannot be value preserving: `Int64` has more possible values than can be represented in an `Int8`.

Note: the ability to retrieve the original value has no bearing on whether a conversion is value preserving.

- When the first argument forms part of a **prepositional phrase**, give it an **argument label**. The argument label should normally begin at the preposition, e.g. `x.removeBoxes(havingLength: 12)`.

An exception arises when the first two arguments represent parts of a single abstraction.

```
a.move(toX: b, y: c)
a.fade(fromRed: b, green: c, blue: d)
```

In such cases, begin the argument label *after* the preposition, to keep the abstraction clear.

```
a.moveTo(x: b, y: c)
a.fadeFrom(red: b, green: c, blue: d)
```

- **Otherwise, if the first argument forms part of a grammatical phrase, omit its label**, appending any preceding words to the base name, e.g. `x.addSubview(y)`

This guideline implies that if the first argument *doesn't* form part of a grammatical phrase, it should have a label.

```
view.dismiss(animated: false)
let text = words.split(maxSplits: 12)
let studentsByName = students.sorted(isOrderedBefore: Student.namePrecede
```

Note that it's important that the phrase convey the correct meaning. The following would be grammatical but would express the wrong thing.

<code>view.dismiss(false)</code>	Don't dismiss? Dismiss a Bool?
<code>words.split(12)</code>	Split the number 12?

Note also that arguments with default values can be omitted, and in that case do not form part of a grammatical phrase, so they should always have labels.

- **Label all other arguments.**

Special Instructions

- **Label closure parameters and tuple members** where they appear in your API.

These names have explanatory power, can be referenced from documentation comments, and provide expressive access to tuple members.

```

/// Ensure that we hold uniquely-referenced storage for at least
/// `requestedCapacity` elements.
///
/// If more storage is needed, `allocate` is called with
/// `byteCount` equal to the number of maximally-aligned
/// bytes to allocate.
///
/// - Returns:
///   - reallocated: `true` iff a new block of memory
///     was allocated.
///   - capacityChanged: `true` iff `capacity` was updated.
mutating func ensureUniqueStorage(
    minimumCapacity requestedCapacity: Int,
    allocate: (byteCount: Int) -> UnsafePointer<Void>
) -> (reallocated: Bool, capacityChanged: Bool)

```

Although when used in closures they are technically argument labels, you should choose these labels and use them in documentation *as though* they were parameter names. A call to the closure in the function body will read consistently with a function whose phrase starting in the base name does not include the first argument:

```
allocate(byteCount: newCount * elementSize)
```

- **Take extra care with unconstrained polymorphism** (e.g. `Any`, `AnyObject`, and unconstrained generic parameters) to avoid ambiguities in overload sets.

For example, consider this overload set:

```

struct Array {
    /// Inserts `newElement` at `self.endIndex`.
    public mutating func append(_ newElement: Element)

    /// Inserts the contents of `newElements`, in order, at
    /// `self.endIndex`.
    public mutating func append(_ newElements: S)
        where S: Generator.Element == Element
}

```

These methods form a semantic family, and the argument types appear at first to be sharply distinct. However, when `Element` is `Any`, a single element can have the same type as a sequence of elements.

```

var values: [Any] = [1, "a"]
values.append([2, 3, 4]) // [1, "a", [2, 3, 4]] or [1, "a", 2, 3, 4]?

```

To eliminate the ambiguity, name the second overload more explicitly.


```
struct Array {  
  /// Inserts `newElement` at `self.endIndex`.  
  public mutating func append(_ newElement: Element)  
  
  /// Inserts the contents of `newElements`, in order, at  
  /// `self.endIndex`.  
  public mutating func append(contentsOf newElements: S)  
    where S: Generator.Element == Element  
}
```

Notice how the new name better matches the documentation comment. In this case, the act of writing the documentation comment actually brought the issue to the API author's attention.