
The Answer To The Ultimate Question of Monads, Programming and Everything

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Abstract

The central thesis of this essay is targeted toward computer programmers of any skill level and concerns itself with answering three questions.

1. What does the term monad mean?

You will have a concrete understanding of the concept that the term monad denotes. You will be able to confidently use the term in discussion and recognise episodes where the term is being used improperly.

2. What does the term monad not mean?

This essay will address many of the popular misunderstandings around the term monad. You will be equipped to determine if you are observing an incident of misappropriation of the term.

3. Why does the concept of a monad matter to me, a computer programmer?

Once you have been introduced to the concept of a monad, you will be introduced to its significance as it applies to typical computer programming tasks.

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Preface

The monad concept is surrounded by mysticism among many programmers. It is poorly understood and its importance is widely under-appreciated. In this essay, I will attempt to provide a concrete understanding of the term and I will also explicitly address many of the common myths. I will also provide insight into the importance of the concept and why it should matter to you.

A few different programming languages will be used; Java, C#, Haskell and Scala to name a few. This is because monads are unrelated to specific programming languages. Indeed, monads are relevant to any typical programming language. However, you are not expected to be intimate with the syntaxes of these various languages. Where there is possibility for the syntax to cause confusion, clarification will be provided.

This essay will not use cute metaphors as in other monad tutorials. Monads are not space-suits or any such notion that may confuse a reader. We will not go into the heavy mathematics behind monads (category theory), however, you will be expected to think somewhat abstractly at times, but only to an extent that you are probably familiar with.

I intend to be thorough in debunking many of the misunderstandings and providing all the tools to help you understand this apparently elusive computer programming concept and its important application. It must be said that monads are a simpler concept than their reputation would have you believe and you will soon see why. I hope you enjoy this essay and it brings you enlightenment and adds to your tools to make you a more effective computer programmer. If you have questions, feedback or criticism, please send it to the mailing list <monad-tutorial@googlegroups.com>.

Introduction

Syntax

This tutorial will use various programming languages, though you needn't be intimately familiar with their differences. It is worth noting however, the differences in function signature syntax. Examples are below.

Example 1. A Java function signature

```
<A> int function(String s, A a) {  
    ...  
}
```

Example 2. A C# function signature

```
Int Function<A>(String s, A a) {  
    ...  
}
```

Example 3. A Scala function signature

```
def function[A](s: String, a: A): Int =  
    ...
```

Example 4. A Haskell function signature

```
function :: String -> a -> Int  
function = ...
```

Terminology

What is a monad? seems to be the question that is most often put forward by curious observers. However, within this question is the implicit assumption of the existence of *a monad* as if it were a thing that has some kind of observable manifestation. Let's not get mystical here; an explanation is in order.

Consider the example of an interface called `CharSequence` in the standard Java library. Here is a shortened version of that interface:

Example 5. `java.lang.CharSequence` (abbreviated)

```
interface CharSequence {  
    char charAt(int index);  
    int length();  
}
```

Now suppose someone put forward the question, *What is a CharSequence?* Notice the potential here for equivocation. “Well it's an interface!” might be an appropriate response. A follow-up question might be *Is a String a CharSequence?* Of course, the answer is yes, so a `String` is a `CharSequence` and `CharSequence` is an interface, therefore, a `String` is an interface. I hope you see the problem here. Attempting to explain this problem might confuse further and give the appearance of appealing to vague and vacuous notions.

The question *What is a monad?* is only as meaningful as the question *What is a CharSequence?* Indeed, if Java's type system were flexible enough, one would begin by writing: `interface Monad` and we would write suitable implementations of this interface and this would provide the answer to *What is a Monad?*. But let's not get carried away just yet.

In this essay, we will avoid referring to *a monad* to avoid this potential for confusion. This may seem like a minor point, but there are many implications and pitfalls if this terminology were to be maintained. “A monad” so to speak, *is an interface*. It's just an interface and nothing more, which is why it may appear intangible (but it's just an interface!), with a few notable remarks:

- The Monad interface cannot be expressed using some static type systems because they are too inflexible. Both Java and C#¹ are examples where this is not possible while it is possible using both Haskell and Scala.

- The Monad interface is both fundamental and extremely useful in every-day programming, much more so than the typical interfaces that you might find.
- The instances of `CharSequence` usually look rather similar and have a general common theme. This can be said about many interfaces. However, the instances for a hypothetical Monad interface can look vastly different, even though they all implement the same interface.

It is the far-reaching implications and incredible usefulness of the monad interface that takes some effort to fully appreciate. So let's do that.

¬Monad

Side-Effects

It is a common misunderstanding that monads are all about side-effects, particularly in a pure functional programming language. It is true that monads can provide a mechanism for controlling side-effects, but this is only one instance of the use of monads.

To draw an analogy, suppose you wrote a function to compute the length of a linked list. If you wrote this function responsibly, it would work on a list of any element type. In other words, the function would be *polymorphic*. You might use this function to compute the length of a list of Banana elements, but this would not be sufficient to say that your length function is in some way related to the Banana type.

Just like you can compute the length of a list of Banana elements, it is also true that you can use monads to represent side-effects, but the relationship does not go any further. In other words, the relationship between monads and side-effects is incredibly weak at a stretch, but non-existent in practical terms. Later on, once we know what monad means, we will see a demonstration of how side-effects can be represented using monads.

To fully appreciate this point, consider that monads are not specific to any particular programming language. For example, monads are relevant in a language that could not possibly be described as a “pure functional programming language”, such as Java. The next section will discuss this.

Monads and Programming Languages

TODO

What does Functor mean?

TODO

What does Monad mean?

TODO

Why do Monads matter to me?

TODO

Monad Instances

Option (Nullable)

TODO

List

TODO

Identity

TODO

Parsers

TODO

Functions

TODO

Continuations

TODO

State

TODO

Side-Effects

TODO

Language Support for Monads

C#/LINQ

TODO

Scala

TODO

Haskell

TODO

OK, so Applicative Functor?

TODO

What about Arrow then?

Monoids

TODO

Arrows

TODO

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