C# and Monads

Bangkok .NET User Group
Will Fuqua
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This Presentation

✓ Topics:

- What is a monad?
- Why use monads?
- C# language features and monads

✗ Not a topic:

- Formal definitions
- How to sneak monads into your code at work

A monad is a container type
that represents an
operation for chaining
its instances.

a monad is a container type...

```
IEnumerable<int> enumerableA =
    Enumerable.Range(1, 3); // 1, 2, 3

IEnumerable<int> enumerableB =
    Enumerable.Range(11, 3); // 11, 12, 13
```

...that represents an operation for chaining its instances

```
// enumerableA is 1, 2, 3
// enumerableB is 11, 12, 13

IEnumerable<(int, int)> pairs =
    from a in enumerableA
    from b in enumerableB
    select (a, b);

// (1, 11) (1, 12) (1, 13) (2, 11)...
```

IEnumerable<T>

is a container type

that represents

cartesian join chaining

of IEnumerable<T> instances

code

Nullable<T>

is a container type

that represents

“stop if null” chaining

of Nullable<T> instances

We've seen what
a monad is.

But what problem
is it solving?

We love generics!

- IEnumerable<T> makes many T
- Nullable<T> makes T optional
- Task<T> makes T asynchronous

… we're giving T superpowers!

We love function composition!

```
int GetIndexOfChar(string s, char c)
char GetCharAtIndex(string s, int i)
```

Given a string and a character, how do we return the next character in the string?

```
char GetNextCharacter(string s, char c) =>
GetCharAtIndex(s, GetIndexOfChar(s, c) + 1)
```

And here's the problem...

Generics do not
work well with composition

```
int? GetIndexOfChar(string s, char c)
char? GetCharAtIndex(string s, int i)
```

```
GetCharAtIndex(s, GetIndexOfChar(s, c) + 1)
```

Compile error!

How can we use generics,
but still be able to
compose functions?

spoiler: monads

How to write a monad

Implement two functions: Unit and Bind

- Unit
- Bind

Optional:

- Implement SelectMany so it works with LINQ

How to write a monad

We can create two simple functions:

```
Nullable<T> Unit<T>(T value)
```

wraps a 'T' value

```
Nullable<TResult> Bind<T, TResult>(
    this Nullable<T> target,
    Func<T, Nullable<TResult>> action)
```

Applies 'action' inside 'target' and returns a flattened object

How to write a monad

```
/// wraps a T value
Nullable<T> Unit<T>(T val) ⇒ new Nullable<T>(val);

/// applies action and returns a flattened value
Nullable<TResult> Bind<T, TResult>(
        this Nullable<T> target,
        Func<T, Nullable<TResult>> action) ⇒
    target.HasValue
        ? action(target.Value)
        : null;
```

```
int? GetIndexOfChar(string s, char c)
char? GetCharAtIndex(string s, int i)
```

We use these functions like this:

```
Nullable<char> result = Unit('H');

Nullable<char> result = GetIndexOfChar(str, 'H')
    .Bind(index ⇒ GetCharAtIndex(str, index + 1));
```

```
int? GetIndexOfChar(string s, char c)
char? GetCharAtIndex(string s, int i)
```

After implementing the LINQ Query Pattern:

```
Nullable<char> result =
    from index in GetIndexOfChar(str, 'H')
    from nextChar in GetCharAtIndex(str, index + 1)
    select nextChar ;
```

Optional: LINQ Query Pattern

```
Nullable<TResult> SelectMany<TSource, TResult>(
        this Nullable<TSource> source,
        Func<TSource, Nullable<TResult>> projector) ⇒
  Bind(source, projector);

Nullable<TResult> SelectMany<TSource, TMiddle, TResult>(
        this Nullable<TSource> source,
        Func<TSource, Nullable<TMiddle>> projector,
        Func<TSource, TMiddle, TResult> selector) ⇒
  source.Bind(source ⇒ projector(source)
              .Bind(result ⇒ Unit(selector(source, result))));
```

more code: three monads

Nullable / Optional

C# special syntax:

```
string sentence = "Hello world!";
char charToFind = 'H';

Nullable<char> result = (charToFind
    .GetIndexOfCharacter(sentence) + 1)
    ?.GetCharacterAtIndexExt(sentence);
```

Using monads instead:

```
string sentence = "Hello world!";
Nullable<char> charToFind = NullableMonad.Unit('H');

Nullable<char> nextChar = charToFind
    .Bind(chr => GetIndexOfCharacter(sentence, chr))
    .Bind(index => GetCharacterAtIndex(sentence, index + 1));
```

Error Handling

C# special syntax:

```
string sentence = "Hello World";
char charToFind = 'H';
try
{
    int index = GetIndexOfCharacterException(sentence, charToFind);
    int nextChar = GetCharacterAtIndexException(sentence, index + 1);
    return nextChar;
}
catch (Exception e)
{
    // e.g. do some logging
    throw;
}
```

Using monads instead:

```
string sentence = "Hello World";
Result<char> charToFind = ResultMonad.Unit('H');

Result<char> nextChar = charToFind
    .Bind(chr => GetIndexOfCharacter(sentence, chr))
    .Bind(index => GetCharacterAtIndex(sentence, index + 1));
```

Async

C# special syntax:

```
Task<string> input = Task.FromResult("24");

string number = await input;
int parsed = await ParseIntAsync(number);
int divided = await DivideByAsync(parsed, 2);
```

Using monads instead:

```
string sentence = "Hello world!";
Task<char> charToFind = AsyncMonad.Unit('H');

Task<char> divided = charToFind
    .Bind(chr => GetIndexOfCharacter(sentence, chr))
    .Bind(index => GetCharacterAtIndex(sentence, index));
```

The main point of monads

- This same pattern occurs in many different places:
  - Combining lists
  - Nullable (optional) values
  - Asynchronous computation
  - Error handling
  - Managing state and side effects
  - Parsing – Sprache
  - and many more, see the language-ext project

Next steps

- Read Eric Lippert's blog post series: Monads
- Play with the louthy/language-ext library
- Explore category theory in C# with Dixin Yan's Category Theory via C#

Thanks!

Downside of C# Monads

- No higher-kinded types
  - We have “parameterized types”
  - But not “parameterized generics”

- No type inference for function return types or parameters

- Not idiomatic C#

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Black

Is the color of coal, ebony, and of outer space. It is the darkest color, the result of the absence of or complete absorption of light.

In two or three columns

Yellow

Is the color of gold, butter and ripe lemons. In the spectrum of visible light, yellow is found between green and orange.

Blue

Is the colour of the clear sky and the deep sea. It is located between violet and green on the optical spectrum.

Red

Is the color of blood, and because of this it has historically been associated with sacrifice, danger and courage.

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Orange	5	24	16

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That’s a lot of money

x

185,244 users

And a lot of users

x

100%

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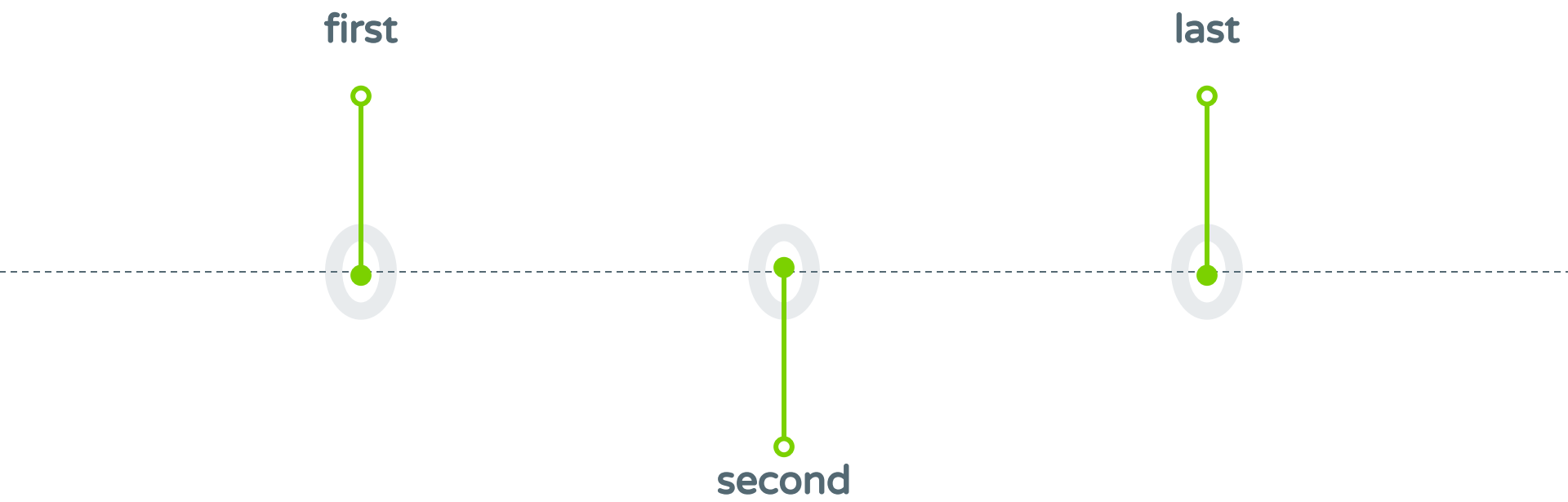

Let’s review some concepts

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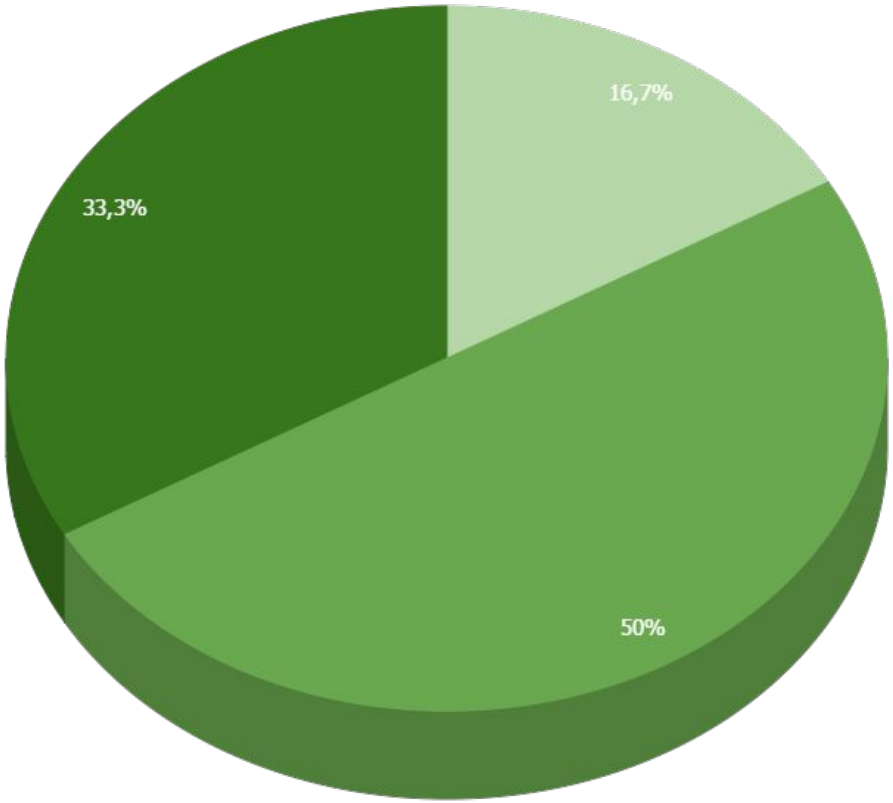

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You can find me at

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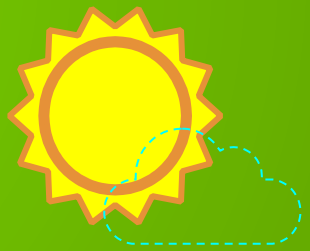

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