Stanford CS193p

Developing Applications for iOS

Spring 2023

Lecture 3

MVVM

- Model-View-ViewModel
  - A "code organizing" architectural design paradigm.
  - Works in concert with the concept of "reactive" user-interfaces.
  - Must be adhered to for SwiftUI to work.
  - It is different from MVC (Model View Controller) that UIKit (old-style iOS) uses.

MVVM

Model

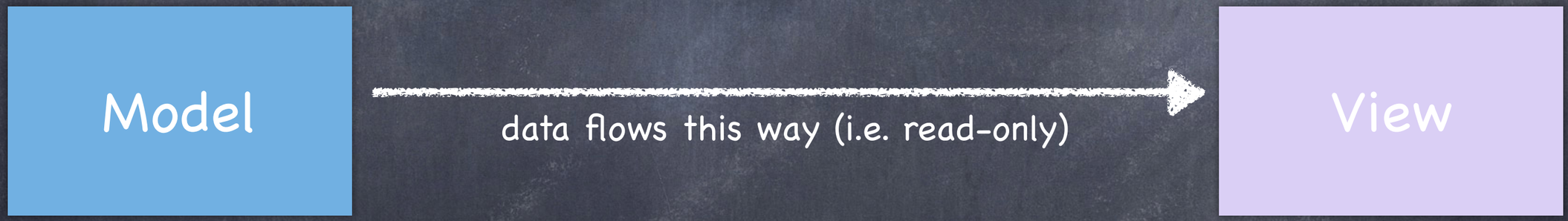
UI Independent

Data + Logic

"The Truth"

View

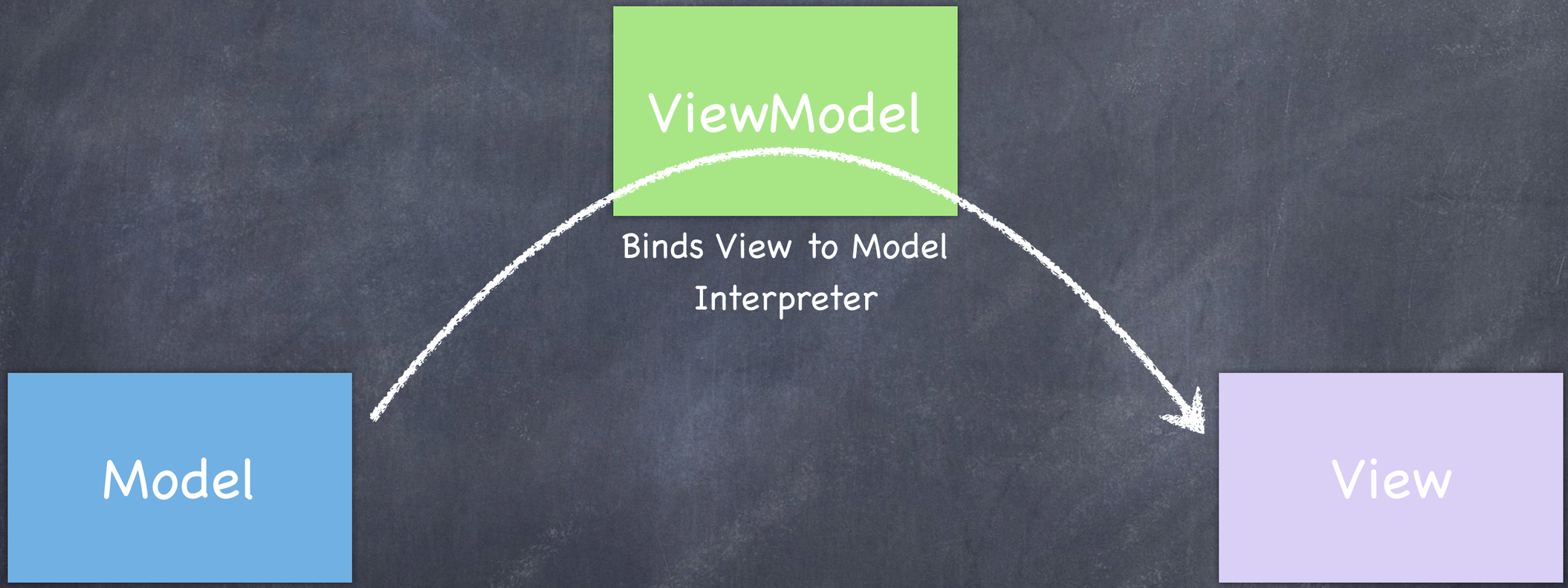
MVVM



UI Independent
Data + Logic
"The Truth"

Reflects the Model
Stateless
Declared
Reactive

MVVM


ViewModel
Binds View to Model
Interpreter
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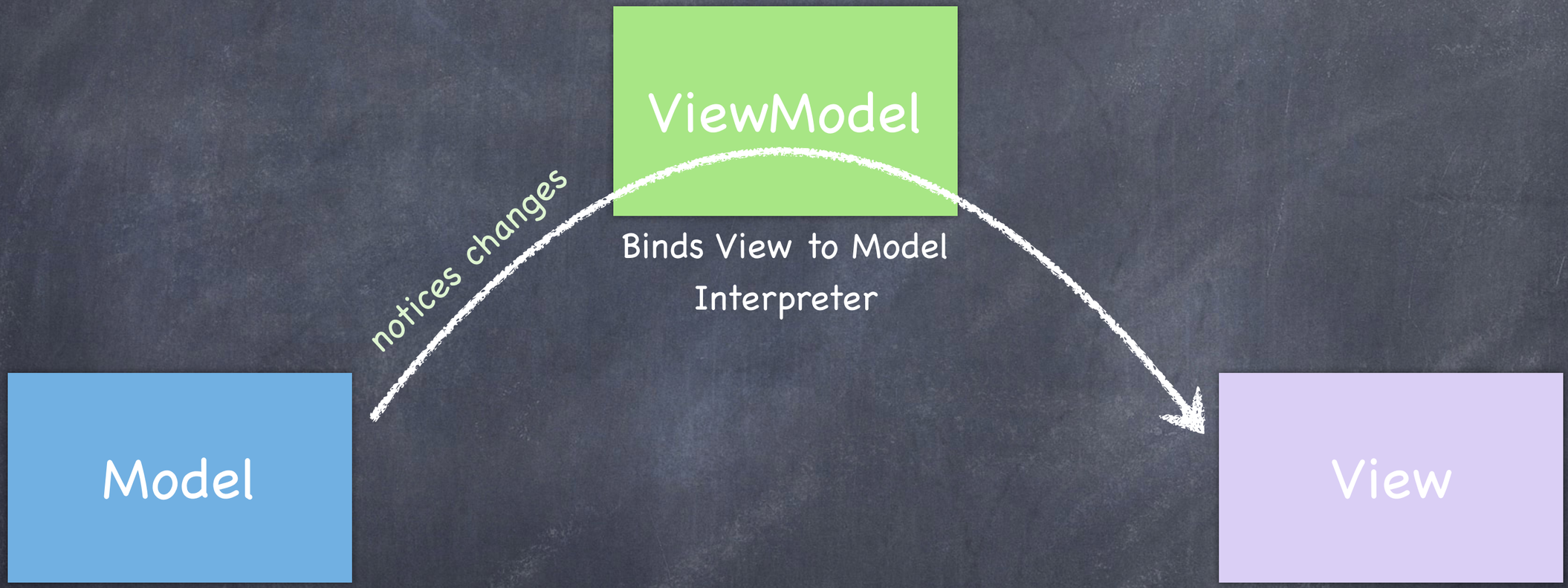
ViewModel
notices changes
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MVVM

might "interpret"

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MVVM

might "interpret"

publishes "something changed"

ViewModel

notices changes

automatically observes publications, pulls data and rebuilds

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MVVM

ObservableObject
@Published
objectWillChange.send()
.environmentObject()

might "interpret"

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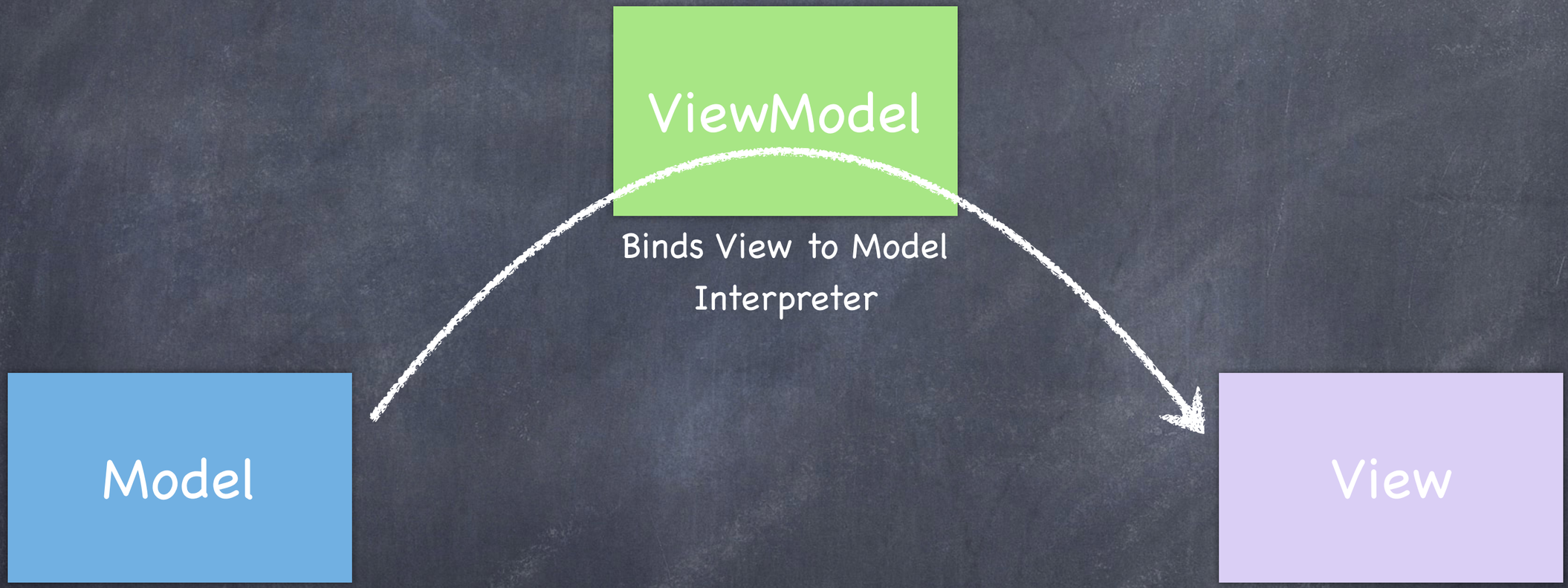
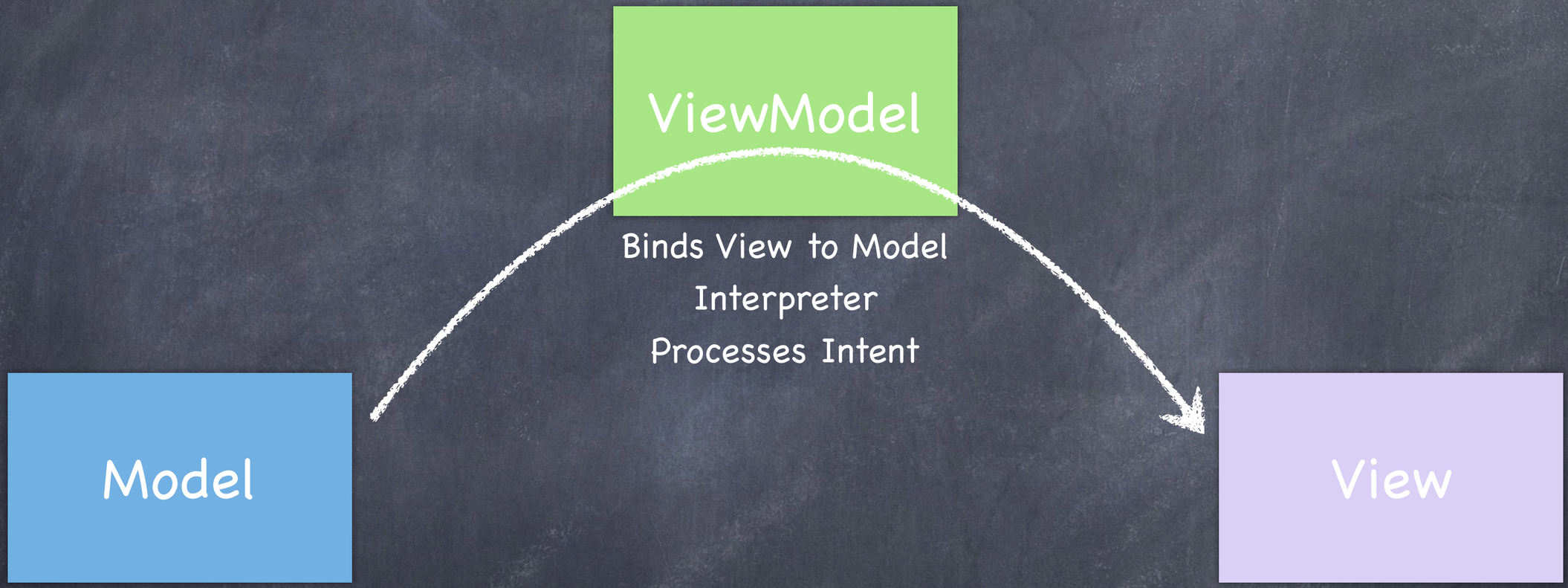


What about the other direction?

MVVM



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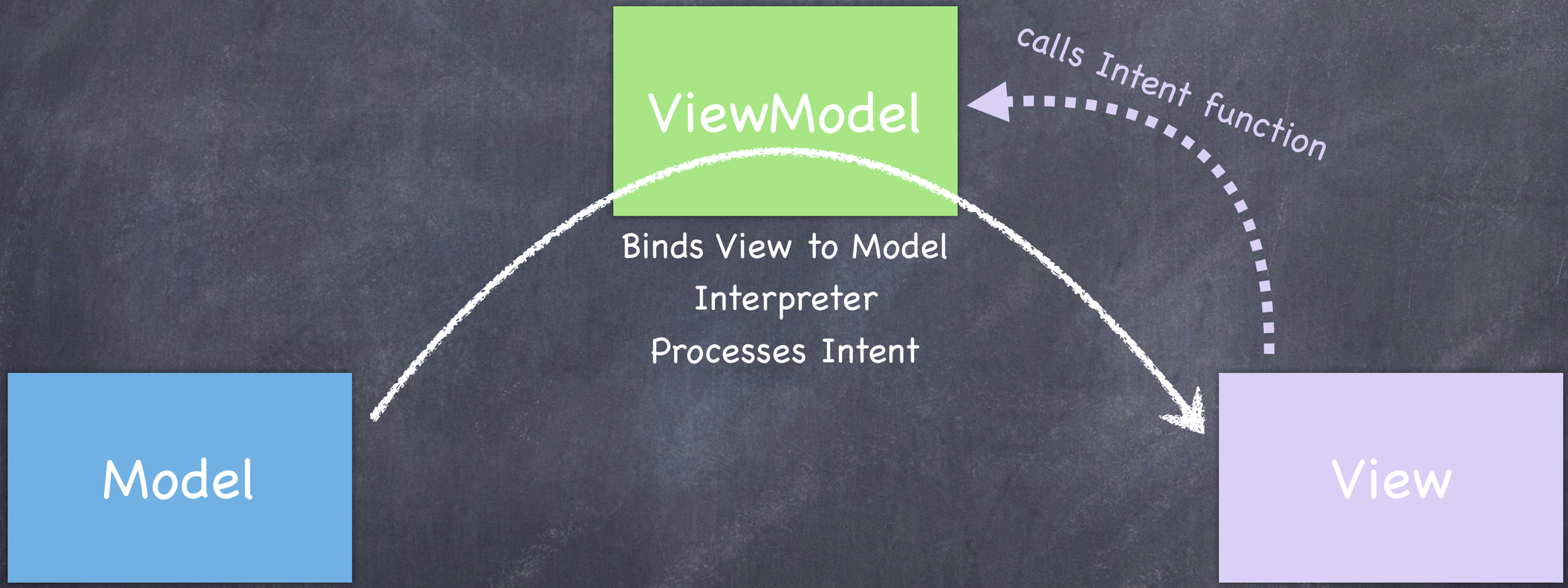

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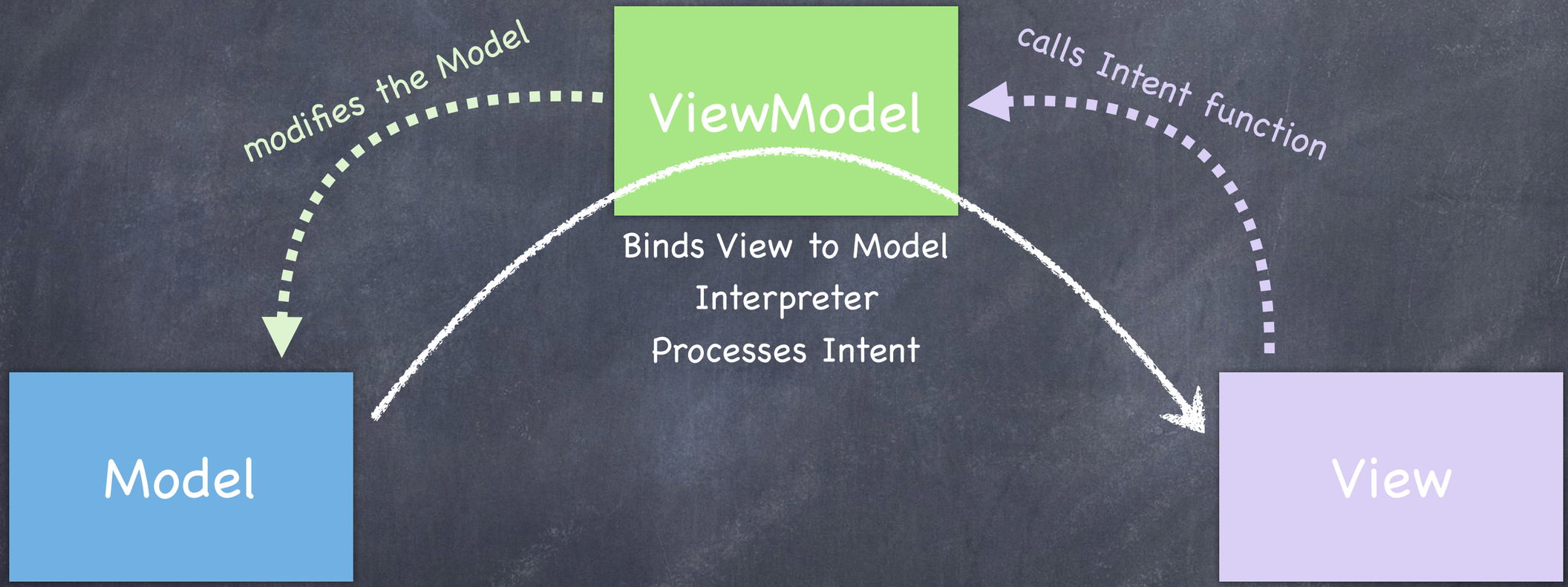

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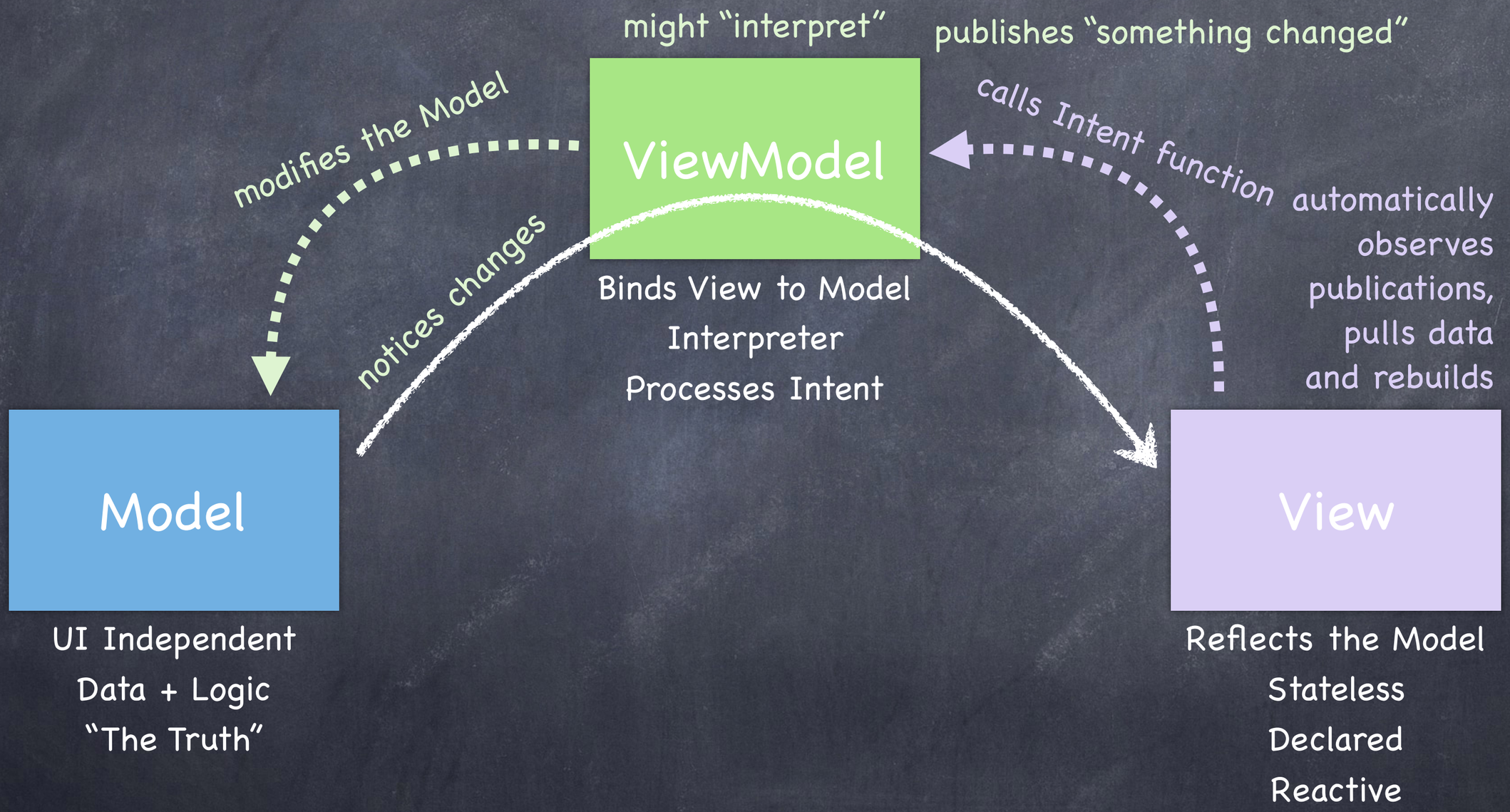
might "interpret"
publishes "something changed"
modifies the Model
calls Intent function
ViewModel
notices changes
automatically observes publications, pulls data and rebuilds
Binds View to Model
Interpreter
Processes Intent
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MVVM

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ObservableObject
@Published
objectWillChange.send()
.environmentObject()
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ViewModel

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Interpreter

Processes Intent

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```
@ObservedObject
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```

Architecture

- MVVM
  - Design paradigm
- Varieties of Types
  - `struct`
  - `class`
  - `protocol`
  - "Dont' Care" type (aka generics)
  - `enum`
  - functions

struct and class

- Both struct and class have …
  - … pretty much exactly the same syntax.
  - stored vars (the kind you are used to, i.e., stored in memory)
  - `var isFaceUp: Bool`

struct and class

- Both struct and class have …
  - … pretty much exactly the same syntax.
  - stored vars (the kind you are used to, i.e., stored in memory)
  - computed vars (i.e. those whose value is the result of evaluating some code)

```
var body: some View {
    return Text(“Hello World”)
}
```

struct and class

- Both struct and class have …
  - … pretty much exactly the same syntax.
  - stored vars (the kind you are used to, i.e., stored in memory)
  - computed vars (i.e. those whose value is the result of evaluating some code)
  - constant lets (i.e. vars whose values never change)

```
let defaultColor = Color.orange
. . .
CardView().foregroundColor(defaultColor)
```

struct and class

- Both struct and class have …
  - … pretty much exactly the same syntax.
  - stored vars (the kind you are used to, i.e., stored in memory)
  - computed vars (i.e. those whose value is the result of evaluating some code)
  - constant lets (i.e. vars whose values never change)
  - functions

```
func multiply(operand: Int, by: Int) -> Int {
    return operand * by
}
multiply(operand: 5, by: 6)

func multiply(_ operand: Int, by otherOperand: Int) -> Int {
    return operand * otherOperand
}
multiply(5, by: 6)
```

struct and class

- Both struct and class have …

  … pretty much exactly the same syntax.

  stored vars (the kind you are used to, i.e., stored in memory)

  computed vars (i.e. those whose value is the result of evaluating some code)

  constant lets (i.e. vars whose values never change)

  functions

  initializers (i.e. special functions that are called when creating a struct or class)

```
struct MemoryGame {
    init(numberOfPairsOfCards: Int) {
        // create a game with that many pairs of cards
    }
}
```

`struct` and `class`

- Both `struct` and `class` have …
  - … pretty much exactly the same syntax.
  - stored `var`s (the kind you are used to, i.e., stored in memory)
  - computed `var`s (i.e. those whose value is the result of evaluating some code)
  - constant `let`s (i.e. `var`s whose values never change)
  - `func`tions
  - `init`ializers (i.e. special functions that are called when creating a `struct` or `class`)
  - So what's the difference between `struct` and `class`?

`struct` and `class`

`struct`

Value type

Copied when passed or assigned

Copy on write

Functional programming

No inheritance

"Free" `init` initializes ALL `var`s

Mutability must be explicitly stated

Your "go to" data structure

Everything you've seen so far is a `struct`
(except `View` which is a `protocol`)

`class`

Reference type

Passed around via pointers

Automatically reference counted

Object-oriented programming

Inheritance (single)

"Free" `init` initializes NO `var`s

Always mutable

Used in specific circumstances

The ViewModel in MVVM is always a `class`
(also, `UIKit` (old style iOS) is `class`-based)

Generics

- Sometimes we just don't care
  - We may want to manipulate data structures that we are "type agnostic" about.
  - In other words, we don't know what type something is and we don't care.
  - But Swift is a strongly-typed language, so we don't use variables and such that are "untyped."
  - So how do we specify the type of something when we don't care what type it is?
  - We use a "don't care" type (we call this feature "generics") ...

Generics

- Example of a user of a "don't care" type: `Array`

  Awesome example of generics: `Array`.

  An `Array` contains a bunch of things and it doesn't care at all what type they are!

  But inside `Array`'s code, it has to have variables for the things it contains. They need types.

  And it needs types for the arguments to `Array` functions that do things like adding items to it.

  Enter ... GENERICS.

Generics

- How Array uses a "don't care" type

  Array's declaration looks something like this ...

```
struct Array<Element> {
    ...
    func append(_ element: Element) { ... }
}
```

  The type of the argument to append is Element. A "don't care" type.

  Array's implementation of append knows nothing about that argument and it does not care.

  Element is not any known struct or class or protocol, it's just a placeholder for a type.

  The code for using an Array looks something like this ...

```
var a = Array<Int>()
a.append(5)
a.append(22)
```

  When someone uses Array, that's when Element gets determined (by Array<Int>).

Generics

- How Array uses a "don't care" type

  Array's declaration looks something like this ...

```
struct Array<Element> {
    ...
    func append(_ element: Element) { ... }
}
```

  Note that Array has to let the world know the names of all of its "don't care" types in its API.

  It does this with the < > notation on its struct declaration Array<Element> above.

  That's how users of Array know that they have to say what type Element actually is.

```
var a = Array<Int>()
```

  It is perfectly legal to have multiple "don't care" types in the above (e.g. <Element, Foo>)

Generics

- Type Parameter

  I will often refer to these types like `Element` in `Array` as a "don't care" type.

  But its actual name is Type Parameter.

  Other languages most of you may know (e.g. Java) have a similar feature.

  However, Swift combines this with `protocols` to take it all to the next level.

  We'll talk about that next week!

Functions as Types

- Functions are people* too! (* er, types)

  You can declare a variable (or parameter to a `func` or whatever) to be of type "function".
  The syntax for this includes the types of the arguments and return value.
  You can do this anywhere any other type is allowed.

  Examples ...

```
(Int, Int) -> Bool   // takes two Ints and returns a Bool
(Double) -> Void     // takes a Double and returns nothing
() -> Array<String>  // takes no arguments and returns an Array of Strings
() -> Void           // takes no arguments and returns nothing (this is a common one)
```

  All of the above a just types. No different than `Bool` or `View` or `Array<Int>`. All are types.

```
var foo: (Double) -> Void // foo's type: "function that takes a Double, returns nothing"
func doSomething(what: () -> Bool) // what's type: "function, takes nothing, returns Bool"
```

Functions as Types

- Functions are people* too! (* er, types)

  Example …

  ```
  var operation: (Double) -> Double
  ```

  This is a `var` called `operation`.

  It is of type "function that takes a `Double` and returns a `Double`".

  Here's a simple function that takes a `Double` and returns a `Double` …

  ```
  func square(operand: Double) -> Double {
      return operand * operand
  }

  operation = square // just assigning a value to the operation var, nothing more
  let result1 = operation(4) // result1 would equal 16
  ```

  Note that we don't use argument labels (e.g. `operand:`) when executing function types.

  ```
  operation = sqrt // sqrt is a built-in function which happens to take and return a Double
  let result2 = operation(4) // result2 would be 2
  ```

  We'll soon see an example of using a function type for a parameter to a function in our demo.

Functions as Types

- Closures

  It's so common to pass functions around that we are very often "inlining" them.
  We call such an inlined function a "closure" and there's special language support for it.
  We'll cover this in the demo and again later in the quarter.

  Remember that we are mostly doing "functional programming" in SwiftUI.
  As the very name implies, "functions as types" is a very important concept in Swift. Very.

Back to the Demo

- MVVM and Types in Action
  - Now that we know about MVVM, let's implement it in our Memorize application
  - In doing so, we'll see a lot of what we just talked about …
  - We're going to use the special `init` function (in both our Model and our ViewModel)
  - We're going to use generics in our implementation of our Model
  - We're going to use a function as a type in our Model
  - We're going to see a `class` for the first time (our ViewModel will be a `class`)
  - We're going to implement an "Intent" in our MVVM
  - And finally, we will make our UI "reactive" through our MVVM design
  - Whew! Let's get started …