#WWDC19

Modern Swift API Design

Ben Cohen, Swift Team
Doug Gregor, Swift Team

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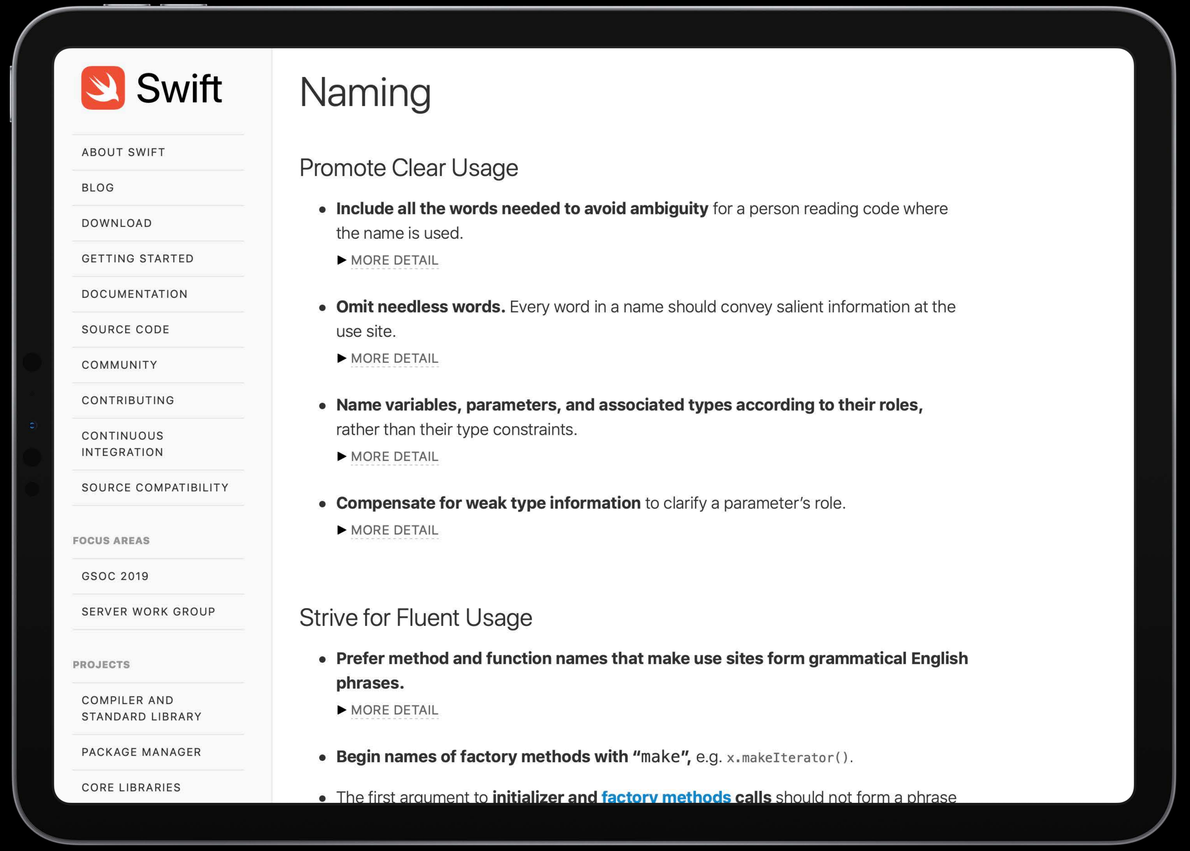
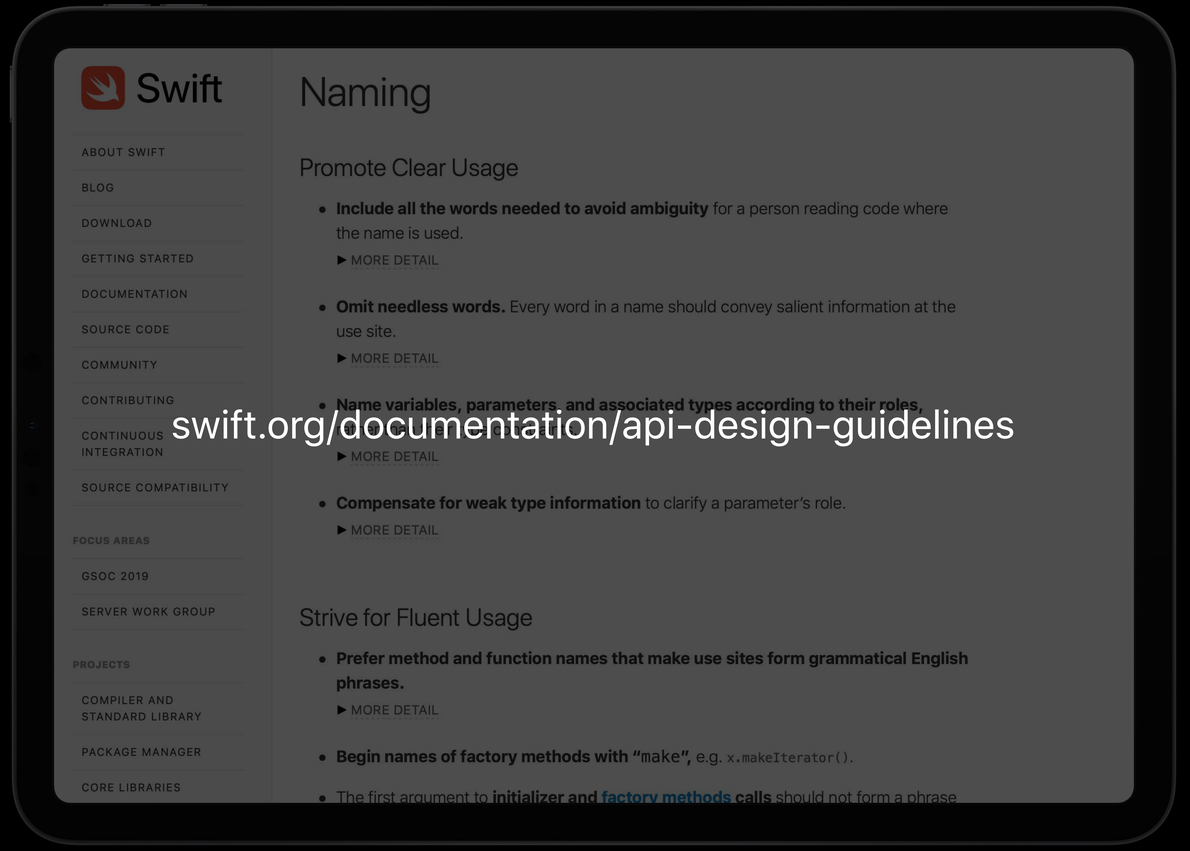
API Design Guidelines



API Design Guidelines



swift.org/documentation/api-design-guidelines

Clarity at the point of use

No Prefixes in Swift-only Frameworks

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C and Objective-C symbols are global

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Swift’s module system allows disambiguation

No Prefixes in Swift-only Frameworks

C and Objective-C symbols are global

Swift's module system allows disambiguation

Remember — each source file brings its imports into the same namespace

Values and references

Protocols and generics

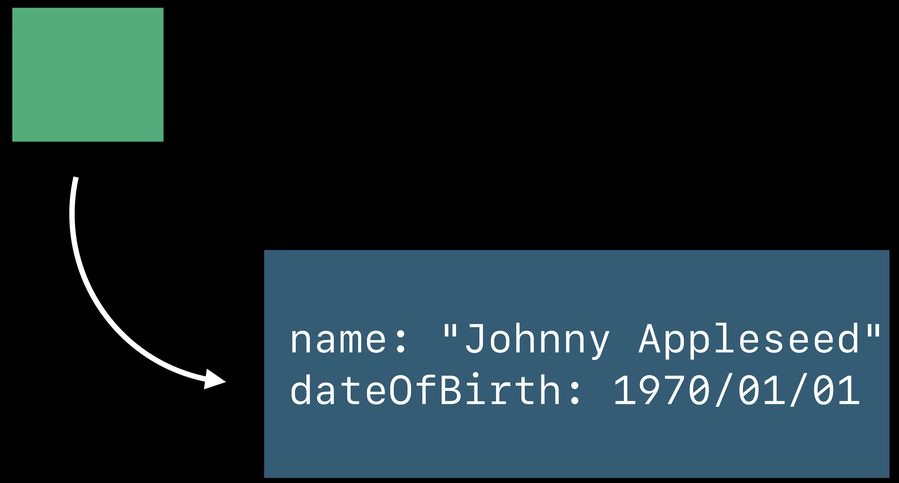
Key path member lookup

Property wrappers

Values and References

Classes — Reference Types

```
class User {
  var name: String
  var dateOfBirth: Date
}
```



Classes — Reference Types

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class User {
  var name: String
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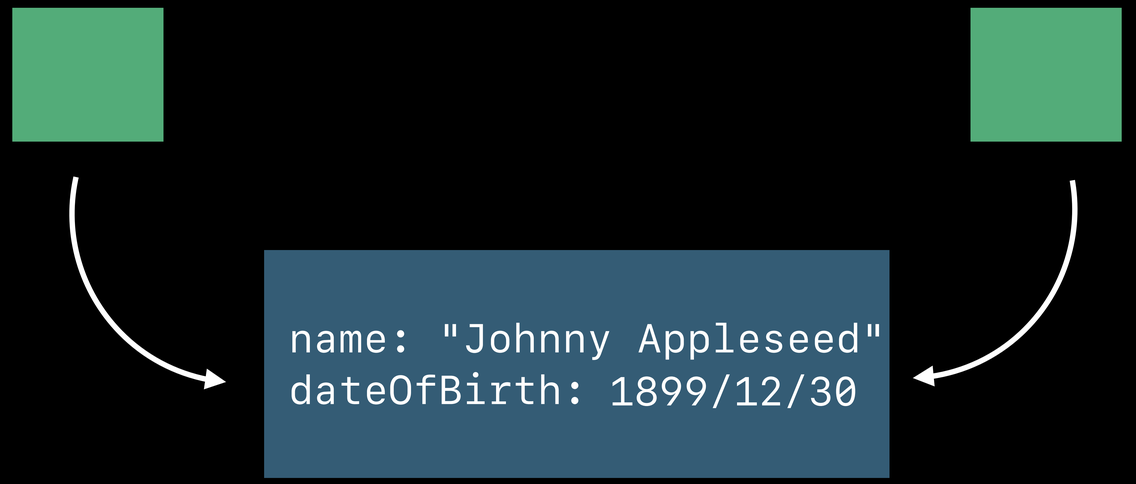

Structs and Enums — Value Types

```
struct User {
  var name: String
  var dateOfBirth: Date
}
```

```
name: "Johnny Appleseed"
dateOfBirth: 1970/01/01
```

Structs and Enums — Value Types

```
struct User {
  var name: String
  var dateOfBirth: Date
}
```

```
name: "Johnny Appleseed"
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```

```
name: "Johnny Appleseed"
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Structs and Enums — Value Types

```
struct User {
  var name: String
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}
```

```
name: "Johnny Appleseed"
dateOfBirth: 1970/01/01
```

```
name: "Johnny Appleseed"
dateOfBirth: 1899/12/30
```

Choosing — Reference or Value?

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Prefer structs over classes

- Only choose classes when reference semantics are important

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Classes can make a good choice when

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Classes can make a good choice when

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- The value is held centrally and shared

Choosing — Reference or Value?

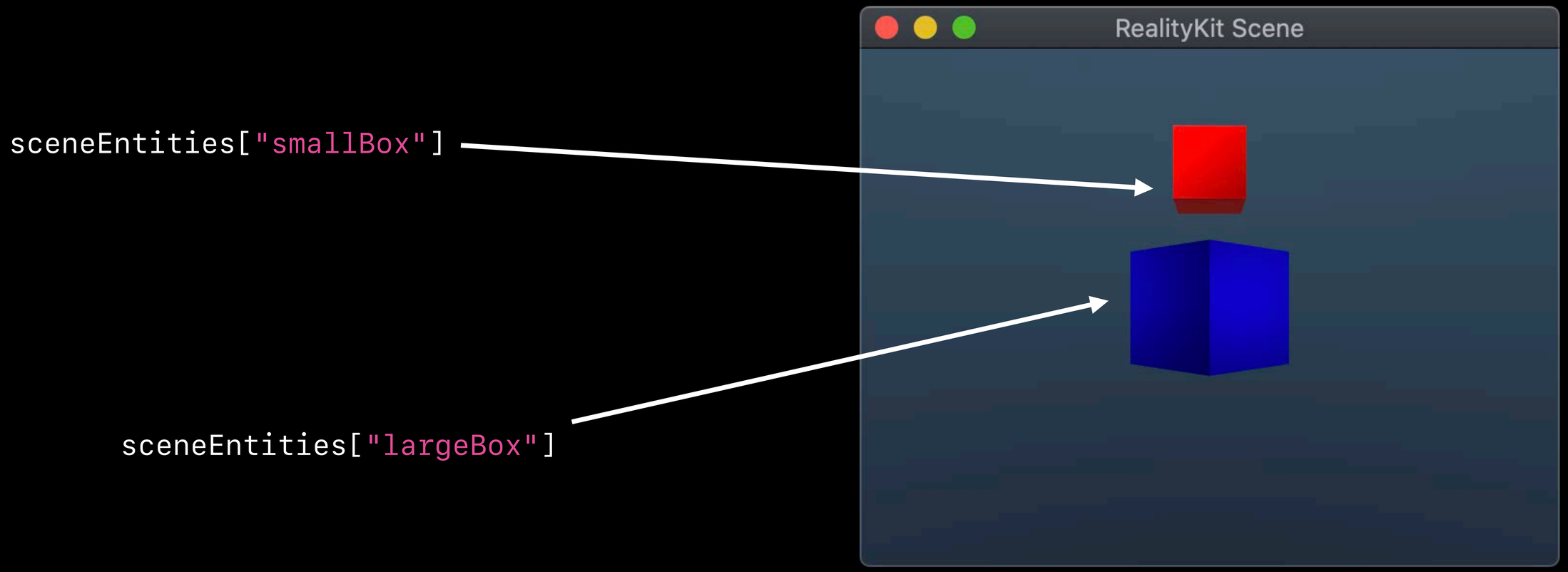
Prefer structs over classes

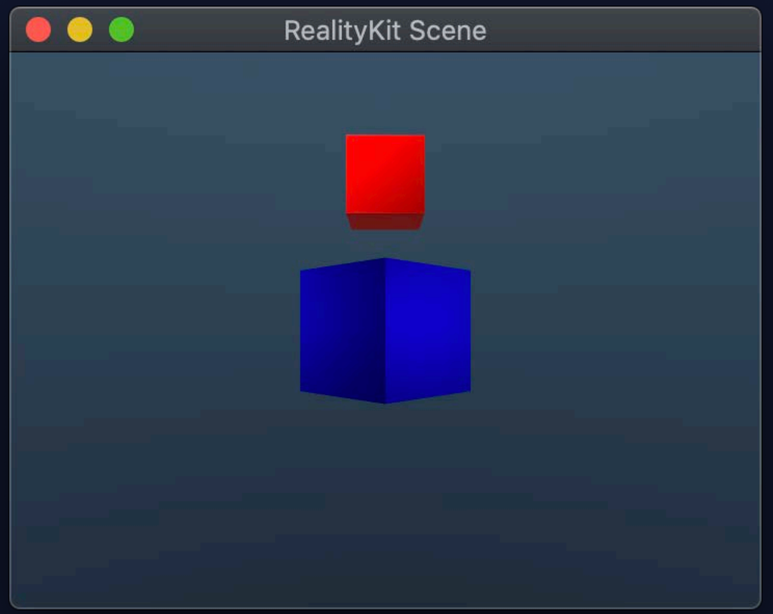
- Only choose classes when reference semantics are important

Classes can make a good choice when

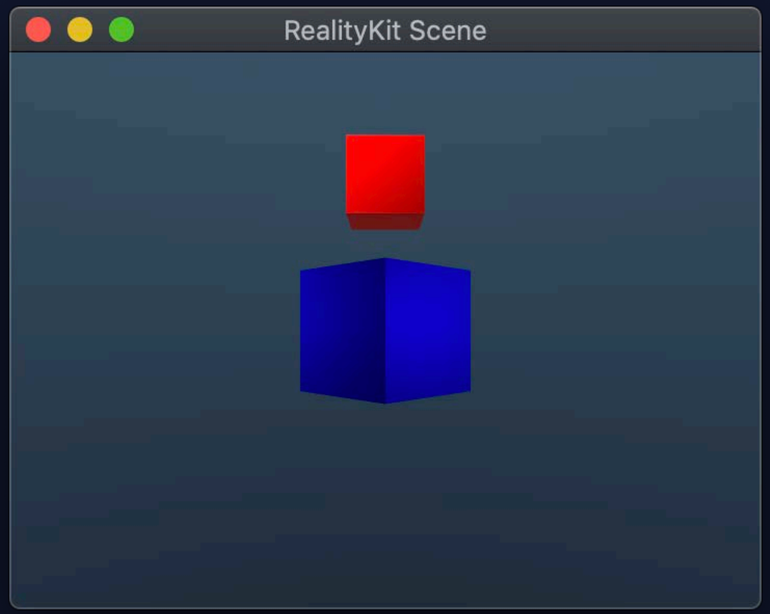
- You need a reference counting and deinitialization
- The value is held centrally and shared
- Where there is a separate notion of “identity” from “equality”

RealityKit — Scenes and Entities




RealityKit Scene

```
var material = SimpleMaterial(color: .blue, roughness: 0.3, isMetallic: true)
let largeBox = ModelEntity(mesh: .generateBox(size: 0.5), materials: [material])
let smallBox = ModelEntity(mesh: .generateBox(size: 0.3), materials: [material])
```



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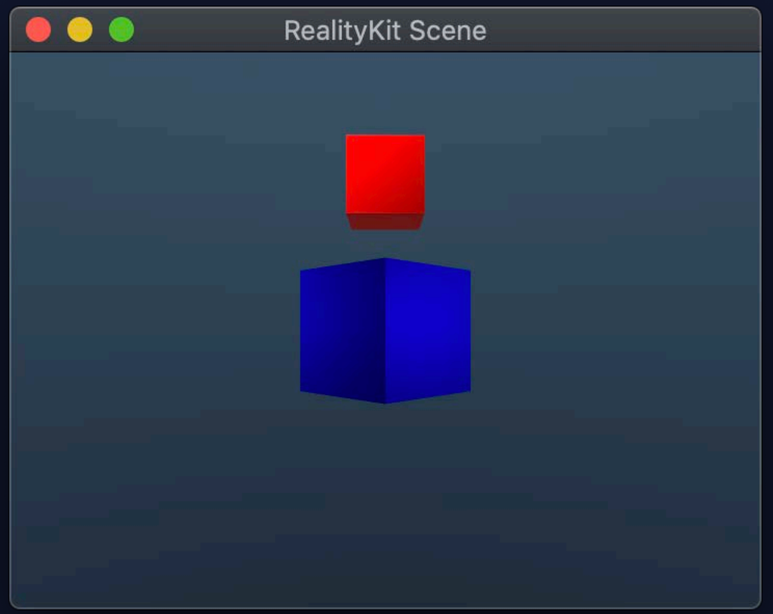
var material = SimpleMaterial(color: .blue, roughness: 0.3, isMetallic: true)
let largeBox = ModelEntity(mesh: .generateBox(size: 0.5), materials: [material])
let smallBox = ModelEntity(mesh: .generateBox(size: 0.3), materials: [material])


let anchor = AnchorEntity()
anchor.children.append(largeBox)
anchor.children.append(smallBox)
arView.scene.anchors.append(anchor)
```



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let largeBox = ModelEntity(mesh: .generateBox(size: 0.5), materials: [material])
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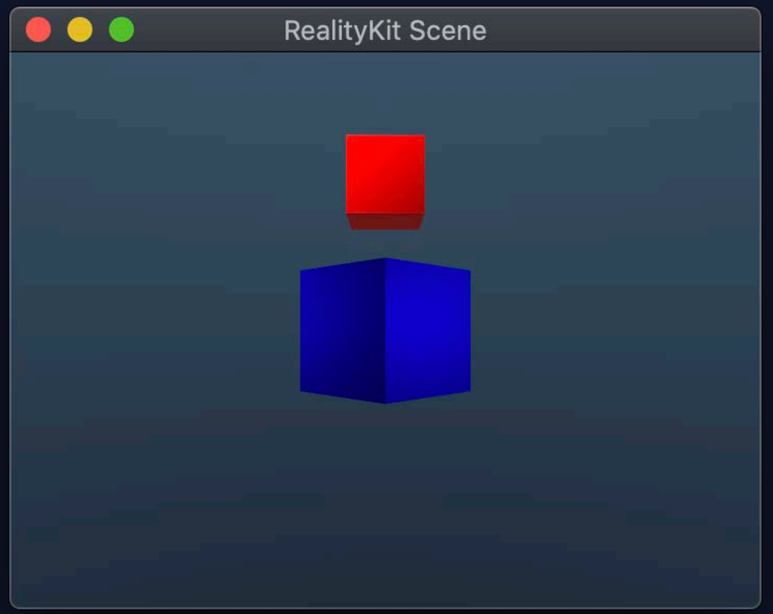
let anchor = AnchorEntity()
anchor.children.append(largeBox)
anchor.children.append(smallBox)
arView.scene.anchors.append(anchor)

smallBox.position.y += 0.6
```



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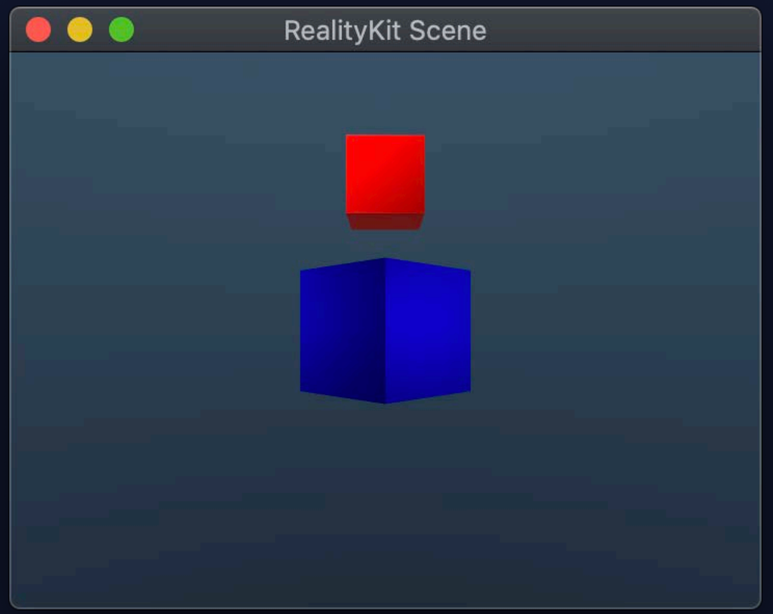
let anchor = AnchorEntity()
anchor.children.append(largeBox)
anchor.children.append(smallBox)
arView.scene.anchors.append(anchor)

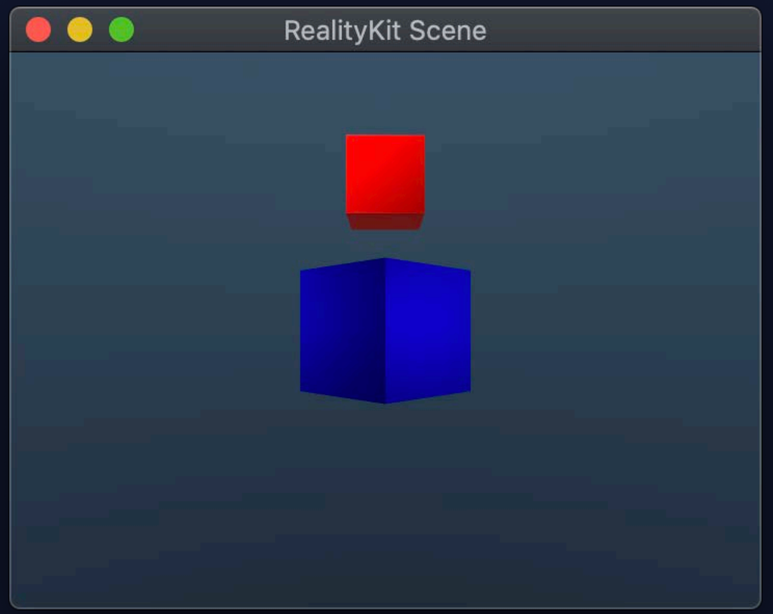
smallBox.position.y += 0.6
largeBox.orientation = .init(angle: .pi/4, axis: [0,1,0])
```



```
var material = SimpleMaterial(color: .blue, roughness: 0.3, isMetallic: true)
let largeBox = ModelEntity(mesh: .generateBox(size: 0.5), materials: [material])
material.tintColor = .red
let smallBox = ModelEntity(mesh: .generateBox(size: 0.3), materials: [material])

let anchor = AnchorEntity()
anchor.children.append(largeBox)
anchor.children.append(smallBox)
arView.scene.anchors.append(anchor)


smallBox.position.y += 0.6
largeBox.orientation = .init(angle: .pi/4, axis: [0,1,0])
```



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  public var roughness: Float
  public var color: Color
  public var texture: Texture
}
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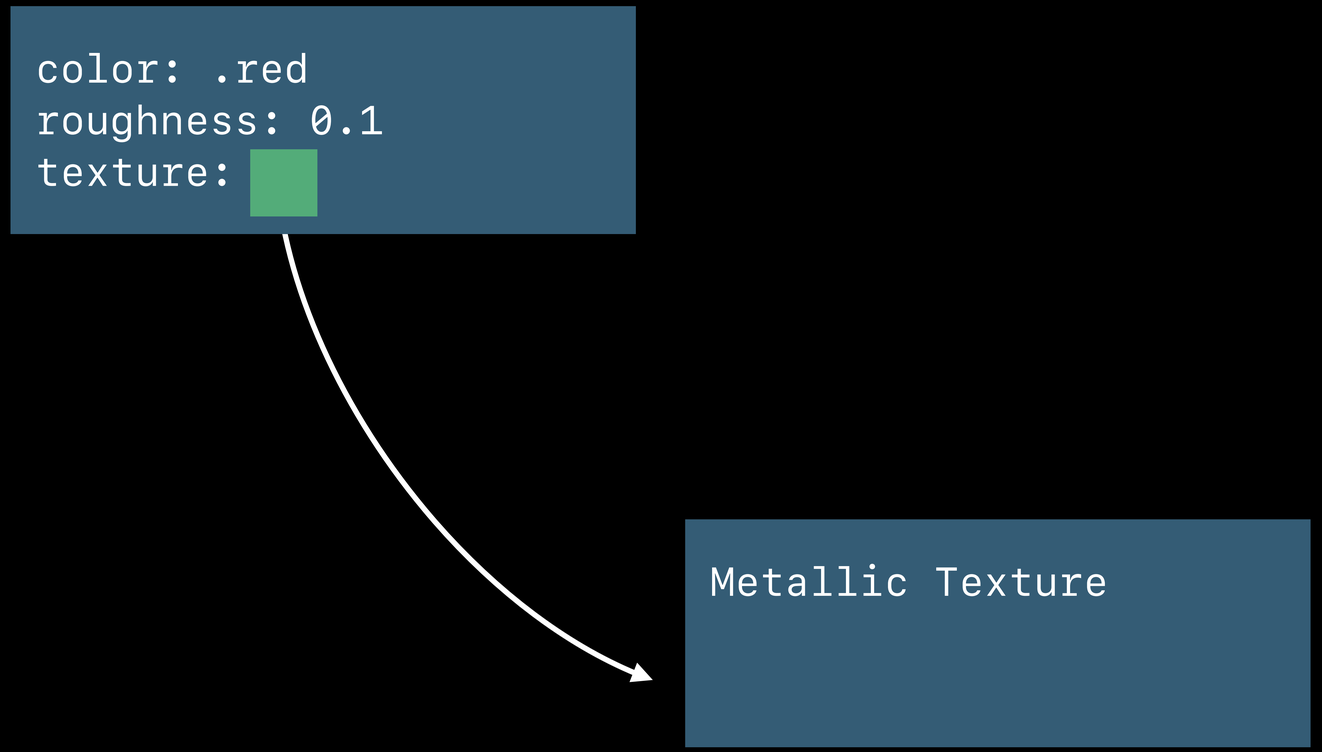
}
```

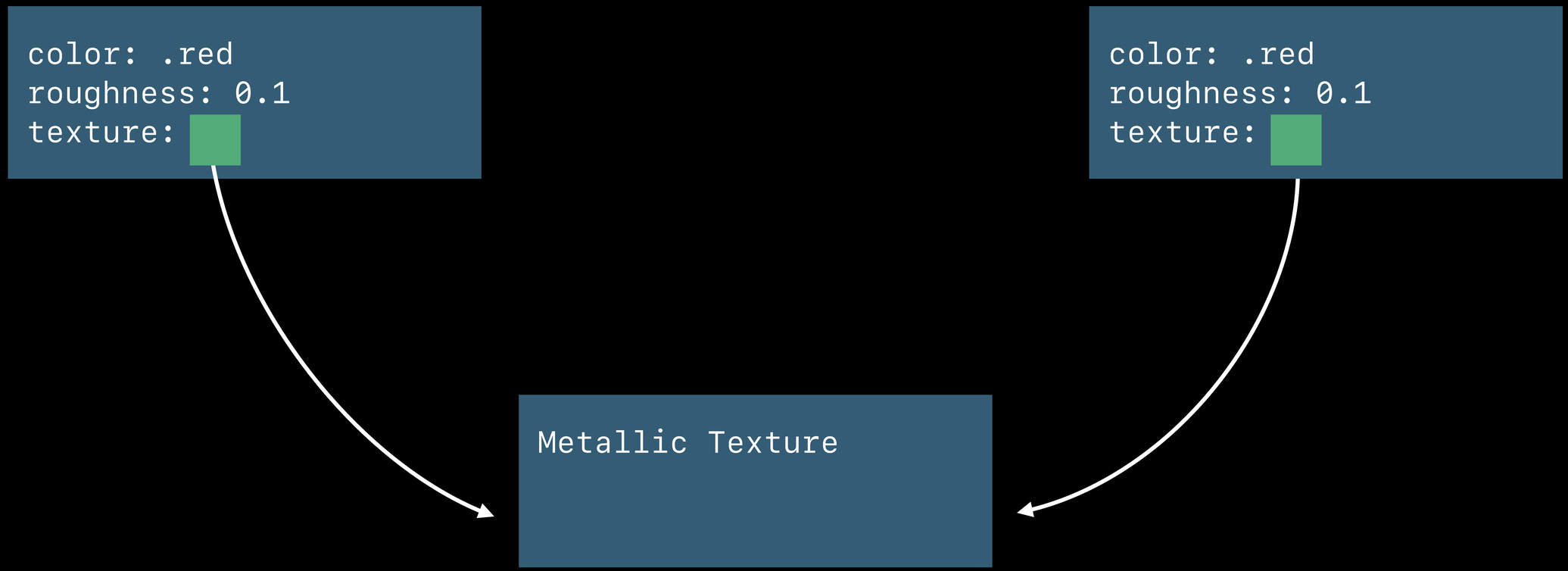
```
struct Material {
  public var roughness: Float
  public var color: Color
  public var texture: Texture
}


class Texture { … }
```

Value Types Make Copies of References



Value Types Make Copies of References



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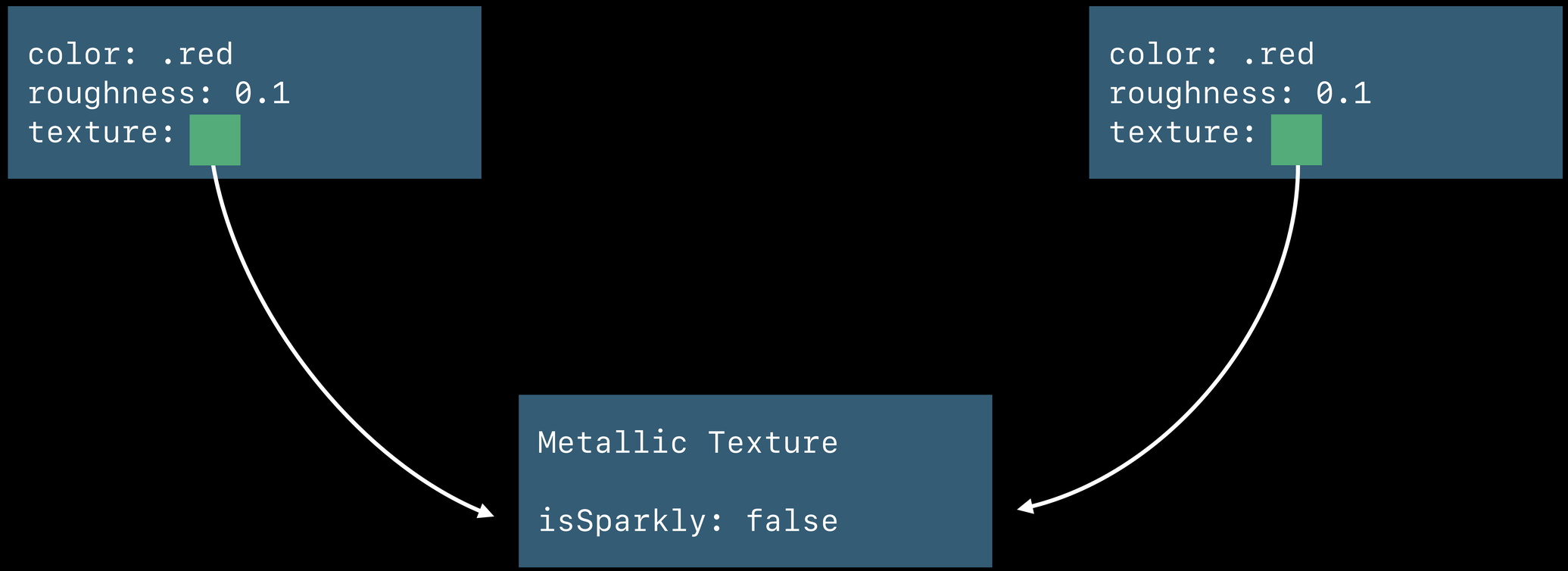

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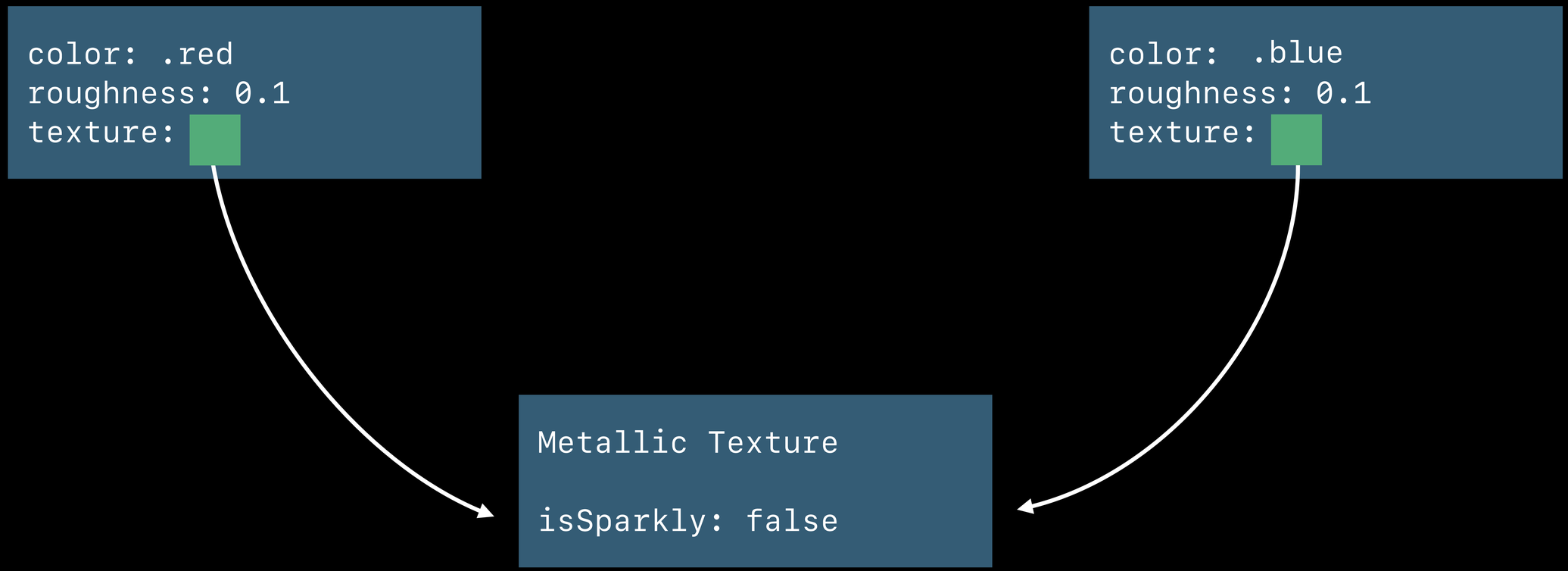

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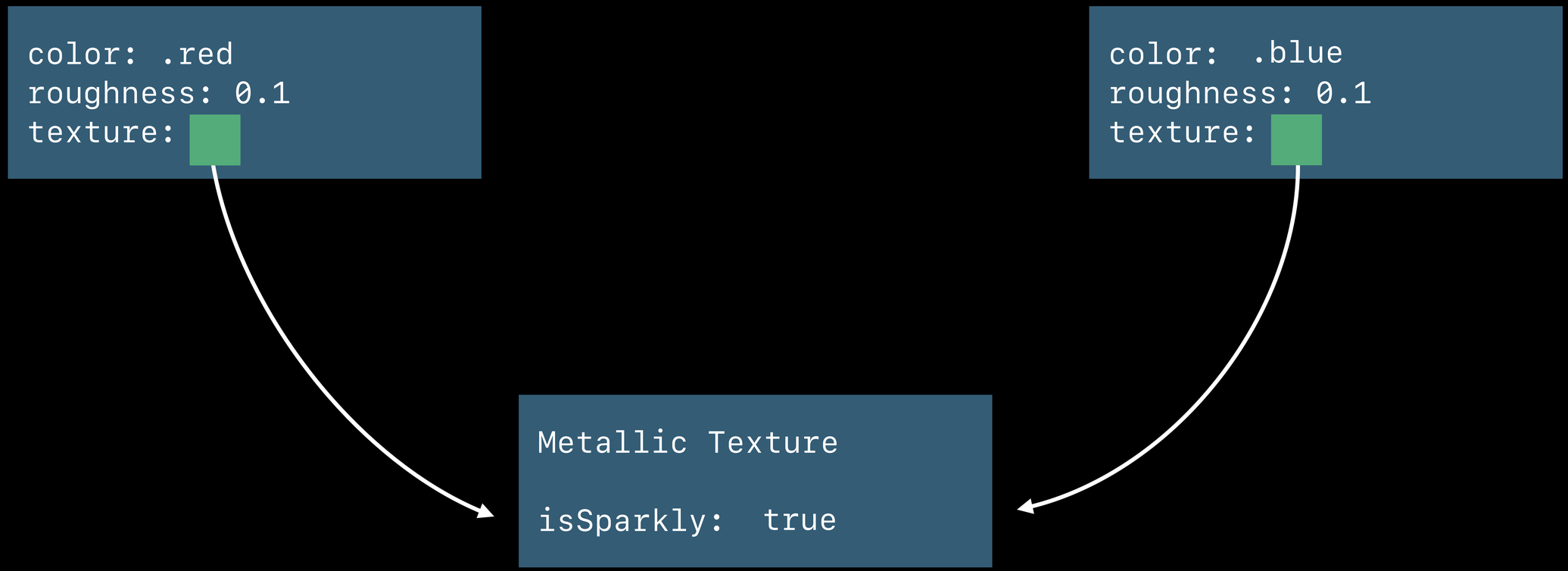
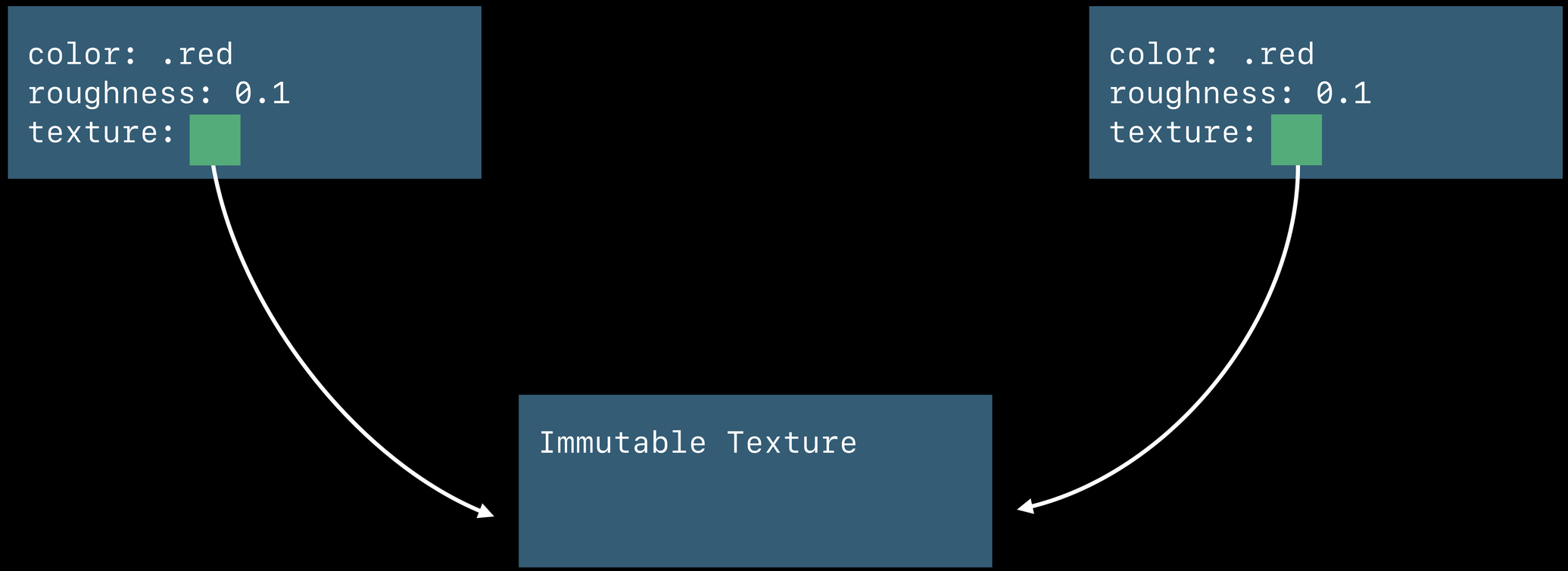


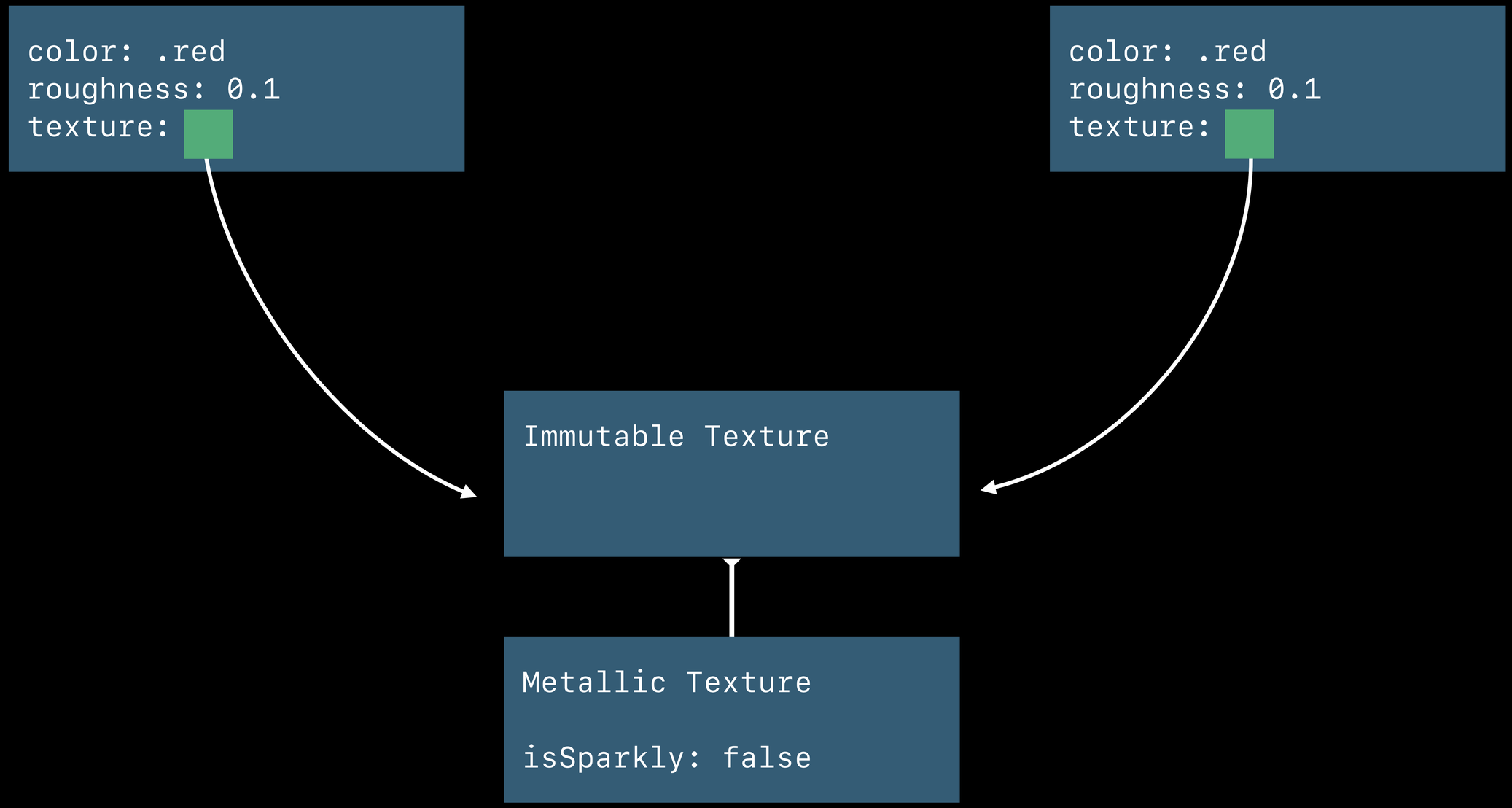
Value and Reference Types

Value and Reference Semantics

Value Types Make Copies of References



Value Types Make Copies of References



```
struct Material {
  public var roughness: Float
  public var color: Color

  public var texture: Texture




}
```

```
struct Material {
  public var roughness: Float
  public var color: Color

  private var _texture: Texture




}
```

```
struct Material {
  public var roughness: Float
  public var color: Color

  private var _texture: Texture

  public var texture {
    get { _texture }
    set { _texture = Texture(copying: newValue) }
  }
}
```

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struct Material {
  public var roughness: Float
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  private var _texture: Texture

  public var texture {
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struct Material {
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}
```

```
struct Material {
  public var roughness: Float
  public var color: Color

  private var _texture: Texture

  public var isSparkly: Bool {
    get { _texture.isSparkly }
    set {


    }
  }
}
```

```
struct Material {
  public var roughness: Float
  public var color: Color

  private var _texture: Texture

  public var isSparkly: Bool {
    get { _texture.isSparkly }
    set {


    }
  }
}
```

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struct Material {
  public var roughness: Float
  public var color: Color

  private var _texture: Texture

  public var isSparkly: Bool {
    get { _texture.isSparkly }
    set {
      if !isKnownUniquelyReferenced(&_texture) { _texture = Texture(copying: _texture)  }
      _texture.isSparkly = newValue
    }
  }
}
```

```
struct Material {
  public var roughness: Float
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    set {
      if !isKnownUniquelyReferenced(&_texture) { _texture = Texture(copying: _texture)  }
      _texture.isSparkly = newValue
    }
  }
}
```

Protocols and Generics

```
// Protocols Can Apply to Value Types
```

```
// Protocols Can Apply to Value Types

class NSOrderedSet: Sequence

struct Array: Sequence

struct CGPoint: Equatable

enum Optional: Equatable where Wrapped: Equatable
```

Don’t Literally Start With a Protocol

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Start with concrete use cases

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Discover a need for generic code

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Try to compose solutions from existing protocols first

Don’t Literally Start With a Protocol

Start with concrete use cases

Discover a need for generic code

Try to compose solutions from existing protocols first

Consider a generic type instead of a protocol

```
protocol GeometricVector {




}
```

```
protocol GeometricVector {
    static func dot(_ a: Self, _ b: Self) -> Scalar

    var length: Scalar { get }

    func distance(to other: Self) -> Scalar
}
```

```
protocol GeometricVector : SIMD {
    static func dot(_ a: Self, _ b: Self) -> Scalar

    var length: Scalar { get }

    func distance(to other: Self) -> Scalar
}
```

```
protocol GeometricVector : SIMD where Scalar: FloatingPoint {
    static func dot(_ a: Self, _ b: Self) -> Scalar

    var length: Scalar { get }

    func distance(to other: Self) -> Scalar
}
```

```
extension GeometricVector {
  static func dot(_ a: Self, _ b: Self) -> Scalar {
    (a * b).sum()
  }

  var length: Scalar {
    Self.dot(self, self).squareRoot()
  }

  func distance(to other: Self) -> Scalar {
    (self - other).length
  }
}
```

```
extension SIMD2: GeometricVector where Scalar: FloatingPoint { }

extension SIMD3: GeometricVector where Scalar: FloatingPoint { }

extension SIMD4: GeometricVector where Scalar: FloatingPoint { }
```

```
extension SIMD2: GeometricVector where Scalar: FloatingPoint { }

extension SIMD3: GeometricVector where Scalar: FloatingPoint { }

extension SIMD4: GeometricVector where Scalar: FloatingPoint { }

// sure why not ¯\_(ツ)_/¯
extension SIMD64: GeometricVector where Scalar: FloatingPoint { }
```

```
extension GeometricVector {
  static func dot(_ a: Self, _ b: Self) -> Scalar {
    (a * b).sum()
  }

  var length: Scalar {
    Self.dot(self, self).squareRoot()
  }

  func distance(to other: Self) -> Scalar {
    (self - other).length
  }
}
```

```swift
extension SIMD where Scalar: FloatingPoint {
  static func dot(_ a: Self, _ b: Self) -> Scalar {
    (a * b).sum()
  }

  var length: Scalar {
    Self.dot(self, self).squareRoot()
  }

  func distance(to other: Self) -> Scalar {
    (self - other).length
  }
}
```

```
protocol GeometricVector: SIMD
```

```
struct GeometricVector<Storage: SIMD> where Storage.Scalar: FloatingPoint {
  typealias Scalar = Storage.Scalar

  var value: Storage

  init(_ value: Storage) { self.value = value }
}
```

```
struct GeometricVector<Storage: SIMD> where Storage.Scalar: FloatingPoint {
  typealias Scalar = Storage.Scalar

  var value: Storage

  init(_ value: Storage) { self.value = value }
}
```

```
extension GeometricVector {
  static func + (a: Self, b: Self) -> Self {
    Self(a.value + b.value)
  }

  static func - (a: Self, b: Self) -> Self {
    Self(a.value - b.value)
  }

  static func * (a: Self, b: Scalar) -> Self {
    Self(a.value * b)
  }
}
```

```
extension GeometricVector {
  static func + (a: Self, b: Self) -> Self {
    Self(a.value + b.value)
  }

  static func - (a: Self, b: Self) -> Self {
    Self(a.value - b.value)
  }

  static func * (a: Self, b: Scalar) -> Self {
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extension GeometricVector {
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    Self(a.value - b.value)
  }

  static func * (a: Self, b: Scalar) -> Self {
    Self(a.value * b)
  }
}
```
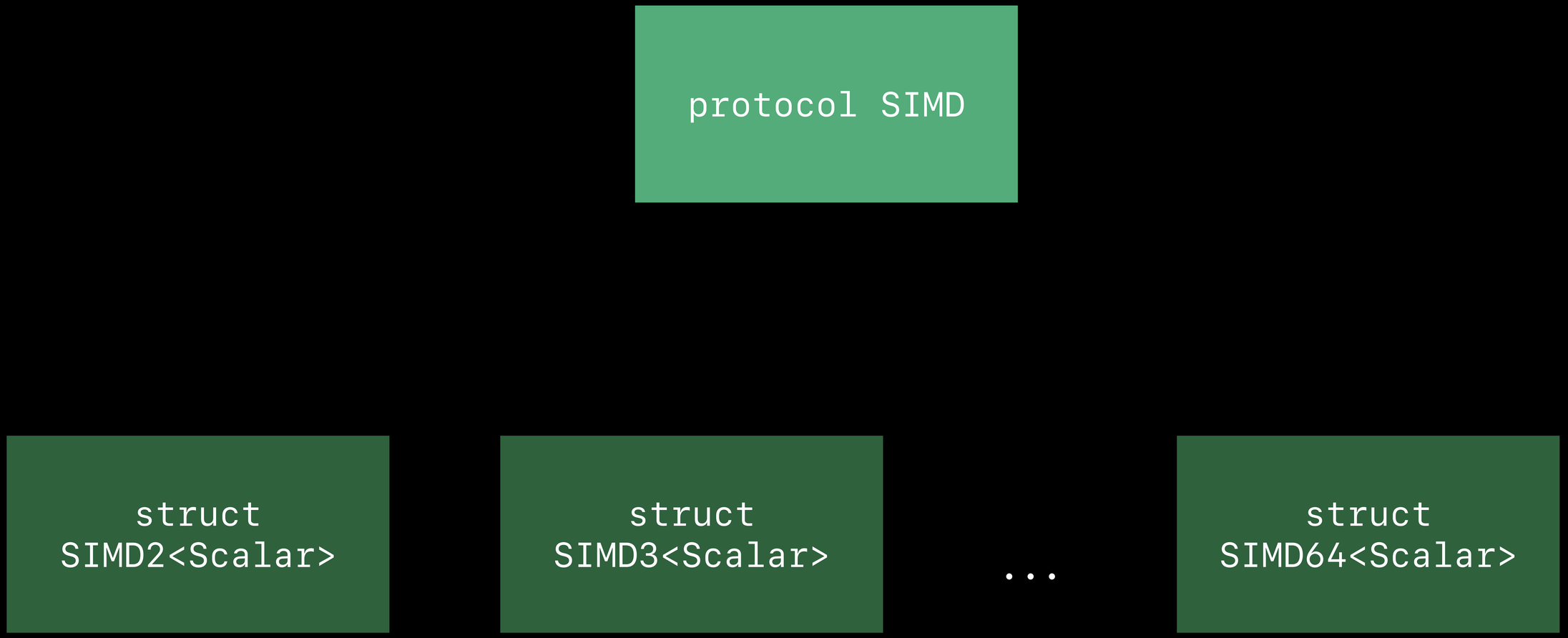

```
extension GeometricVector {
  static func dot(_ a: Self, _ b: Self) -> Scalar {
    (a.value * b.value).sum()
  }

  var length: Scalar {
    Self.dot(self, self).squareRoot()
  }

  func distance(to other: Self) -> Scalar {
    (self - other).length
  }
}
```

SIMD Protocol and Structs



```
infix operator × : MultiplicationPrecedence

extension SIMD3 where Scalar: FloatingPoint {
  /// Cross product for two vectors
  static func × (_ a: Self, _ b: Self) -> Self {
    Self(
      a.y*b.z - a.z*b.y,
      a.z*b.x - a.x*b.z,
      a.x*b.y - a.y*b.x
    )
  }
}
```

```swift
extension GeometricVector {
  /// Cross product for two vectors
  static func ✕ <T>(_ a: Self, _ b: Self) -> Self where Storage == SIMD3<T> {
    Self([
      a.value.y*b.value.z - a.value.z*b.value.y,
      a.value.z*b.value.x - a.value.x*b.value.z,
      a.value.x*b.value.y - a.value.y*b.value.x,
    ])
  }
}
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      a.value.x*b.value.y - a.value.y*b.value.x,
    ])
  }
}
```

Key Path Member Lookup

Swift Evolution: SE-0252

```swift
@dynamicMemberLookup
struct GeometricVector<Storage: SIMD> where Storage.Scalar: FloatingPoint {
  var value: Storage

  init(_ value: Value) { self.value = value }

  subscript(dynamicMember keyPath: KeyPath<Storage, Scalar>) -> Scalar {
    value[keyPath: keyPath]
  }
}
```

```
@dynamicMemberLookup
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  var value: Storage

  init(_ value: Value) { self.value = value }

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```
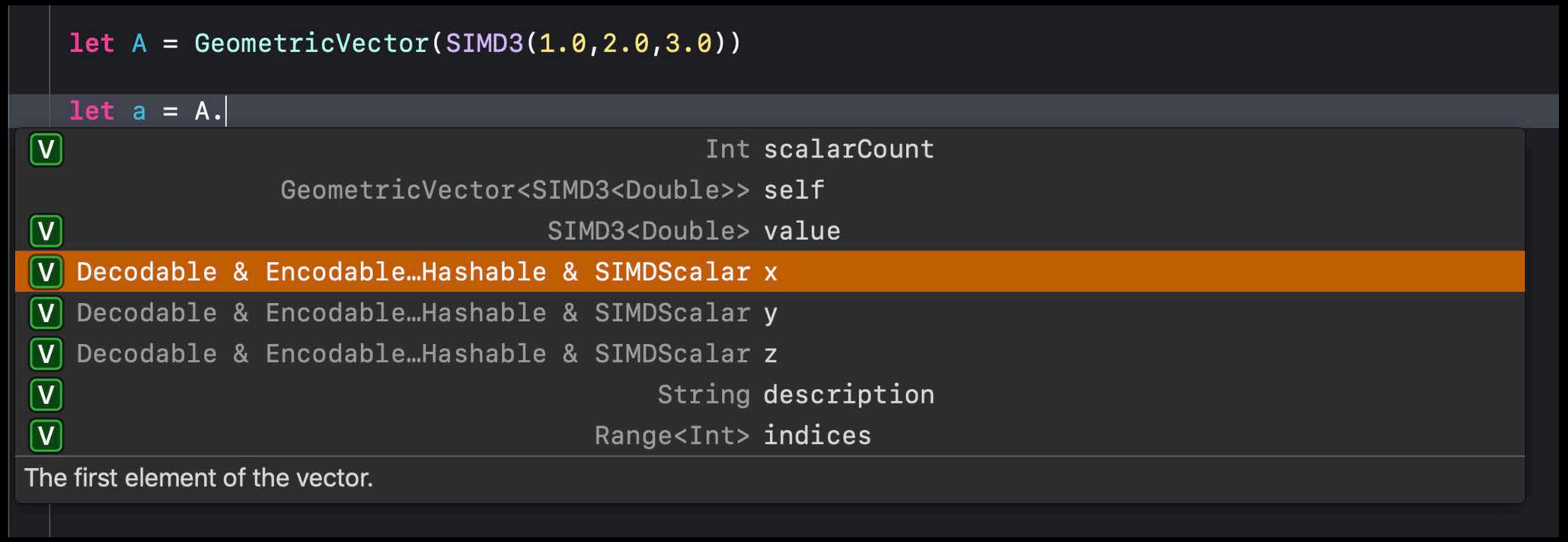

SIMD Properties Now Available on GeometricVector



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extension GeometricVector {
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  static func ✕ <T>(_ a: Self, _ b: Self) -> Self where Storage == SIMD3<T> {
    Self([
      a.value.y*b.value.z - a.value.z*b.value.y,
      a.value.z*b.value.x - a.value.x*b.value.z,
      a.value.x*b.value.y - a.value.y*b.value.x,
    ])
  }
}
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extension GeometricVector {
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    Self([
      a.y*b.z - a.z*b.y,
      a.z*b.x - a.x*b.z,
      a.x*b.y - a.y*b.x,
    ])
  }
}
```

```
struct Material {
  public var roughness: Float
  public var color: Color

  private var _texture: Texture

  public var isSparkly: Bool {
    get { _texture.isSparkly }
    set {
      if !isUniquelyReferenced(&_texture) { _texture = Texture(copying: _texture)  }
      _texture.isSparkly = newValue
    }
  }
}
```

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struct Material {
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  public subscript<T>(dynamicMember keyPath: ReferenceWritableKeyPath<Texture, T>) -> T {




  }
}
```

```
@dynamicMemberLookup
struct Material {
  public var roughness: Float
  public var color: Color

  private var _texture: Texture

  public subscript<T>(dynamicMember keyPath: ReferenceWritableKeyPath<Texture, T>) -> T {




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@dynamicMemberLookup
struct Material {
  public var roughness: Float
  public var color: Color

  private var _texture: Texture

  public subscript<T>(dynamicMember keyPath: ReferenceWritableKeyPath<Texture, T>) -> T {
    get { _texture[keyPath: keyPath] }
    set {
      if !isKnownUniquelyReferenced(&_texture) { _texture = Texture(copying: _texture)  }
      _texture[keyPath: keyPath] = newValue
    }
  }
}
```

```
@dynamicMemberLookup
struct Material {
  public var roughness: Float
  public var color: Color

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}
```

Property Wrappers

Swift Evolution: SE-0258

Doug Gregor, Swift Team

```
// Wrapping a Stored Property

public struct MyType {
  var imageStorage: UIImage? = nil

  public var image: UIImage {
    mutating get {
      if imageStorage == nil {
        imageStorage = loadDefaultImage()
      }
      return imageStorage!
    }
    set {
      imageStorage = newValue
    }
  }
}
```

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      }
      return imageStorage!
    }
    set {
      imageStorage = newValue
    }
  }
}
```

```
// Wrapping a Stored Property

public struct MyType {


  public lazy var image: UIImage = loadDefaultImage()









}
```

```
// Wrapping Another Stored Property

public struct MyType {
  var textStorage: String? = nil

  public var text: String {
    get {
      guard let value = textStorage else {
        fatalError("text has not yet been set!")
      }
      return value
    }
    set {
      textStorage = newValue
    }
  }
}
```

Property Wrappers

Capture backing storage property and access policy for re-use

```
public struct MyType {
  @LateInitialized public var text: String
}
```

Property Wrappers

Capture backing storage property and access policy for re-use

```
public struct MyType {
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}
```

Provides similar benefits to the built-in `lazy`

- Eliminates boilerplate
- Documents semantics at the point of definition

```
// Implementing a Property Wrapper
@propertyWrapper
public struct LateInitialized<Value> {
  private var storage: Value?

  public init() {
    storage = nil
  }

  public var value: Value {
    get {
      guard let value = storage else {
        fatalError("value has not yet been set!")
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      return value
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      return value
    }
    set {
      storage = newValue
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}
```

Using Property Wrappers

Uses of property wrappers expand into a stored property and a computed property

```
public struct MyType {
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}
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Using Property Wrappers

Uses of property wrappers expand into a stored property and a computed property

```
public struct MyType {
  @LateInitialized public var text: String

  // Compiler-synthesized code…
  var $text: LateInitialized<String> = LateInitialized<String>()

  public var text: String {
    get { $text.value }

    set { $text.value = newValue }
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  @LateInitialized public var text: String

  // Compiler-synthesized code…
  var $text: LateInitialized<String> = LateInitialized<String>()

  public var text: String {
    get { $text.value }

    set { $text.value = newValue }
  }
}
```

```swift
// Defensive Copying

@propertyWrapper
public struct DefensiveCopying<Value: NSCopying> {
  private var storage: Value

  public init(initialValue value: Value) {
    storage = value.copy() as! Value
  }

  public var value: Value {
    get { storage }
    set {
      storage = newValue.copy() as! Value
    }
  }
}
```

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// Defensive Copying

@propertyWrapper
public struct DefensiveCopying<Value: NSCopying> {
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  }

  public var value: Value {
    get { storage }
    set {
      storage = newValue.copy() as! Value
    }
  }
}
```

Using the `DefensiveCopying` Property Wrapper

`@DefensiveCopying` variables can be initialized in their declaration:

```
public struct MyType {
  @DefensiveCopying public var path: UIBezierPath = UIBezierPath()
}
```

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```
public struct MyType {
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```

Using the `DefensiveCopying` Property Wrapper

`@DefensiveCopying` variables can be initialized in their declaration:

```
public struct MyType {
  @DefensiveCopying public var path: UIBezierPath = UIBezierPath()

  // Compiler-synthesized code…
  var $path: DefensiveCopying<UIBezierPath> =
      DefensiveCopying(initialValue: UIBezierPath())

  public var path: UIBezierPath {
    get { $path.value }

    set { $path.value = newValue }
  }
}
```

Using the `DefensiveCopying` Property Wrapper

`@DefensiveCopying` variables can be initialized in their declaration:

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public struct MyType {
  @DefensiveCopying public var path: UIBezierPath = UIBezierPath()

  // Compiler-synthesized code…
  var $path: DefensiveCopying<UIBezierPath> =
      DefensiveCopying(initialValue: UIBezierPath())

  public var path: UIBezierPath {
    get { $path.value }

    set { $path.value = newValue }
  }
}
```

Using the `DefensiveCopying` Property Wrapper

```
extension DefensiveCopying {
  public init(withoutCopying value: Value) {
    storage = value
  }
}
```

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```
extension DefensiveCopying {
  public init(withoutCopying value: Value) {
    storage = value
  }
}
```

Initializing the backing storage property:

```
public struct MyType {
  @DefensiveCopying public var path: UIBezierPath

  public init() {
    $path = DefensiveCopying(withoutCopying: UIBezierPath())
  }
}
```

Using the `DefensiveCopying` Property Wrapper

```
extension DefensiveCopying {
  public init(withoutCopying value: Value) {
    storage = value
  }
}
```

Initializing the backing storage property:

```
public struct MyType {
  @DefensiveCopying(withoutCopying: UIBezierPath())
  public var path: UIBezierPath
}
```

API Design with Property Wrappers

Property wrappers describe the policy behind your data access

Lots of API revolves around data access

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Property wrappers describe the policy behind your data access

Lots of API revolves around data access

```
@UserDefault(key: "BOOSTER_IGNITED", defaultValue: false)
static var isBoosterIgnited: Bool
```

API Design with Property Wrappers

Property wrappers describe the policy behind your data access

Lots of API revolves around data access

```
@UserDefault(key: "BOOSTER_IGNITED", defaultValue: false)
static var isBoosterIgnited: Bool

@ThreadSpecific var localPool: MemoryPool
```

API Design with Property Wrappers

Property wrappers describe the policy behind your data access

Lots of API revolves around data access

```
@UserDefault(key: "BOOSTER_IGNITED", defaultValue: false)
static var isBoosterIgnited: Bool

@ThreadSpecific var localPool: MemoryPool

@Option(shorthand: "m", documentation: "Minimum value", defaultValue: 0)
var minimum: Int
```

Property Wrappers in SwiftUI

View data dependencies are expressed using property wrappers

```
struct SlideViewer: View {
  @State private var isEditing = false
  @Binding var slide: Slide









}
```

Property Wrappers in SwiftUI

View data dependencies are expressed using property wrappers

```
struct SlideViewer: View {
  @State private var isEditing = false
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  var body: some View {
    VStack {
      Text("Slide #\(slide.number)")
      if isEditing {
        TextField($slide.title)
      }
      // …
    }
  }
}
```

Property Wrappers in SwiftUI

View data dependencies are expressed using property wrappers

```
struct SlideViewer: View {
  @State private var isEditing = false
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  var body: some View {
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      Text("Slide #\(slide.number)")
      if isEditing {
        TextField($slide.title)
      }
      // …
    }
  }
}
```

```
// Property Wrappers & Key Path Member Lookup

@propertyWrapper
public struct Binding<Value> {
  public var value: Value {
    get { … }
    nonmutating set { … }
  }



}
```

```swift
// Property Wrappers & Key Path Member Lookup

@propertyWrapper @dynamicMemberLookup
public struct Binding<Value> {
  public var value: Value {
    get { … }
    nonmutating set { … }
  }

  public subscript<Property>(dynamicMember keyPath: WritableKeyPath<Value, Property>)
      -> Binding<Property> { … }
}
```

```
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@propertyWrapper @dynamicMemberLookup
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}

@Binding var slide: Slide

slide       // Slide instance
slide.title // String instance
```

```
// Property Wrappers & Key Path Member Lookup

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@Binding var slide: Slide

slide       // Slide instance       $slide       // Binding<Slide> instance
slide.title // String instance
```

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@Binding var slide: Slide

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slide.title // String instance      $slide.title
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@Binding var slide: Slide

slide       // Slide instance       $slide       // Binding<Slide> instance
slide.title // String instance      $slide[dynamicMember: \Slide.title]
```

```
// Property Wrappers & Key Path Member Lookup

@propertyWrapper @dynamicMemberLookup
public struct Binding<Value> {
  public var value: Value {
    get { … }
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@Binding var slide: Slide

slide       // Slide instance       $slide       // Binding<Slide> instance
slide.title // String instance      $slide.title // Binding<String> instance
```

Summary

Value semantics vs. reference semantics

Use protocols for code reuse — not classification

Property wrappers reuse computed property definitions

More Information

developer.apple.com/wwdc19/415

Swift Open Hours	Thursday, 3:00
Swift Open Hours	Friday, 9:00


WWDC19