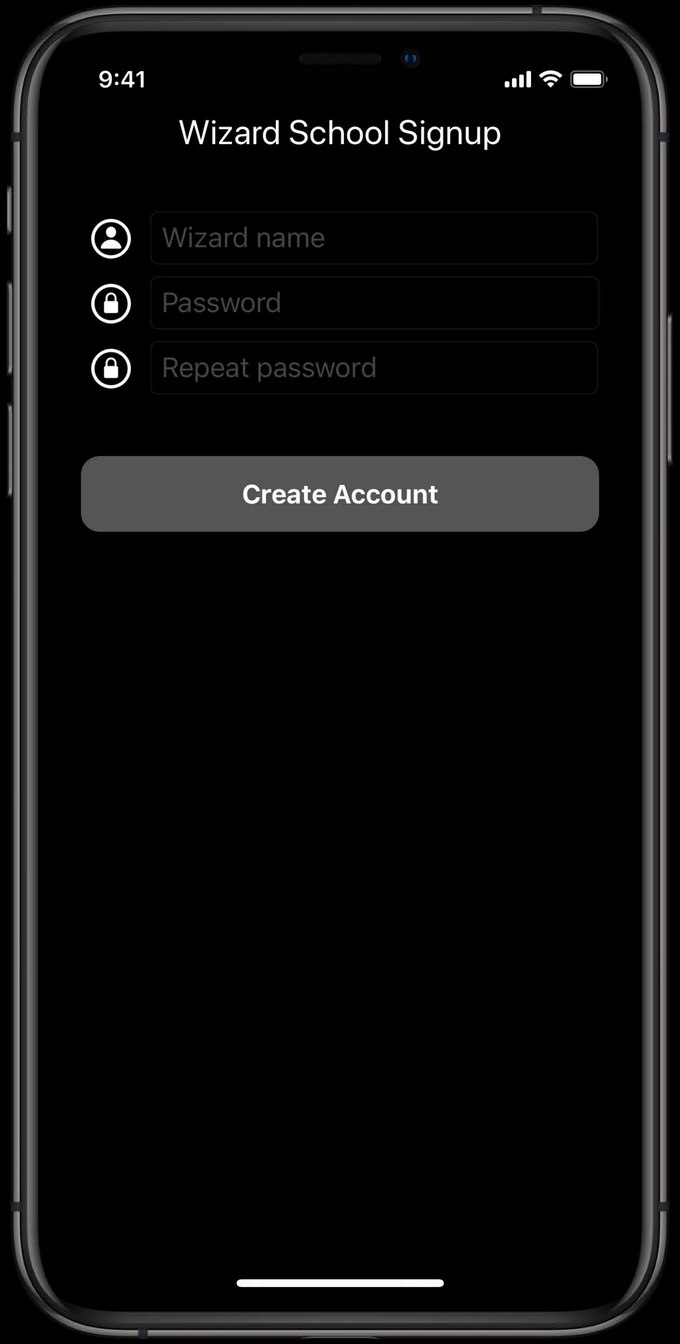
#WWDC19

Introducing Combine

Tony Parker, Foundation

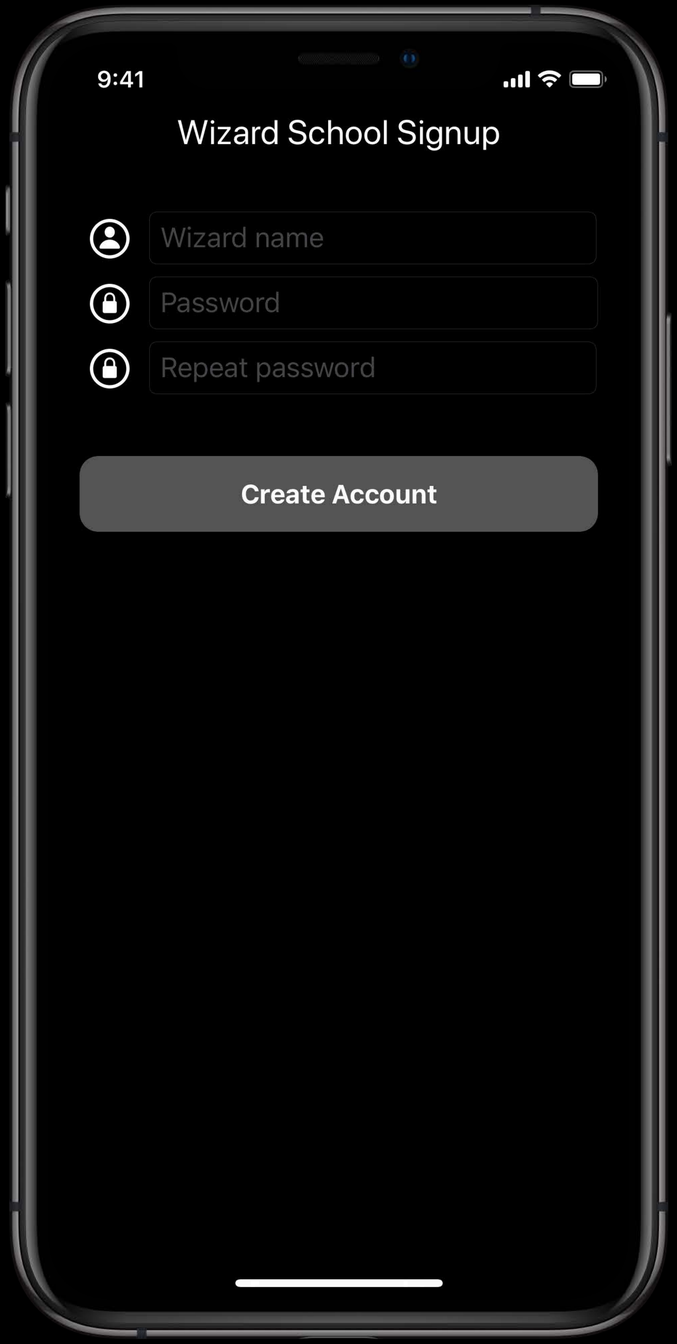

9:41
Wizard School Signup
Wizard name
Password
Repeat password
Create Account

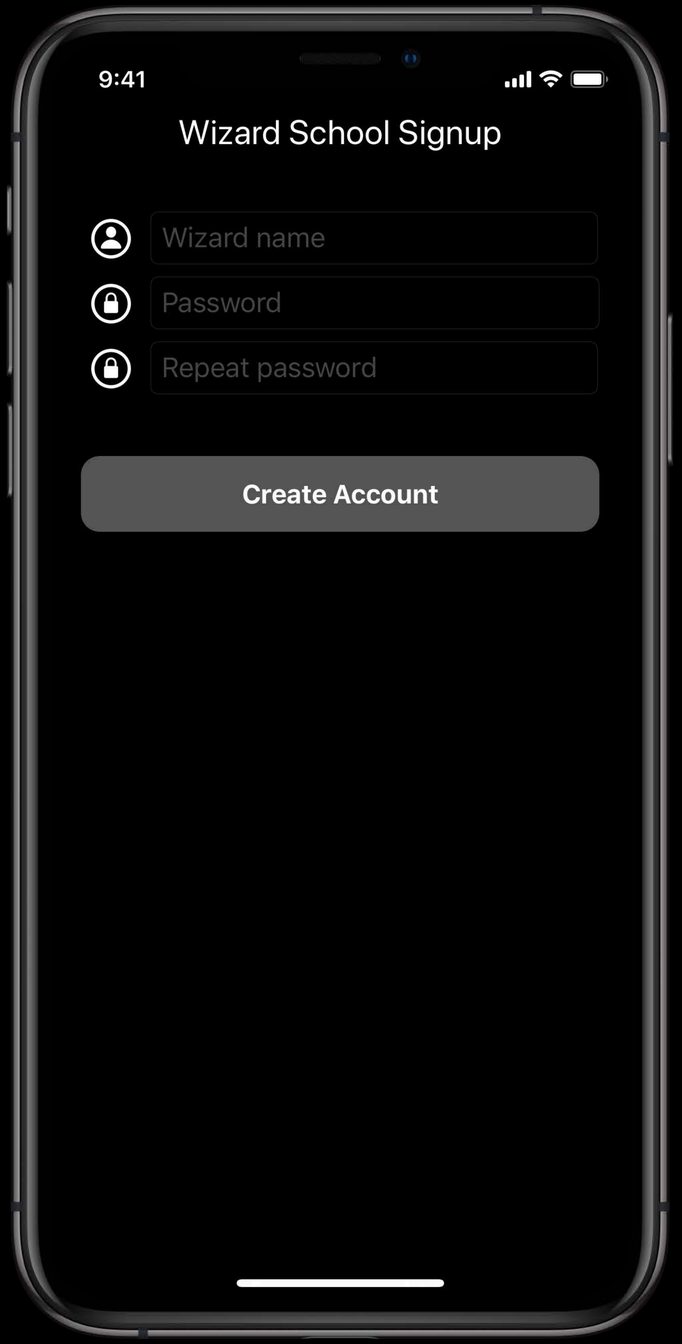
App Requirements

Valid user name

Matching passwords

Responsive user interface

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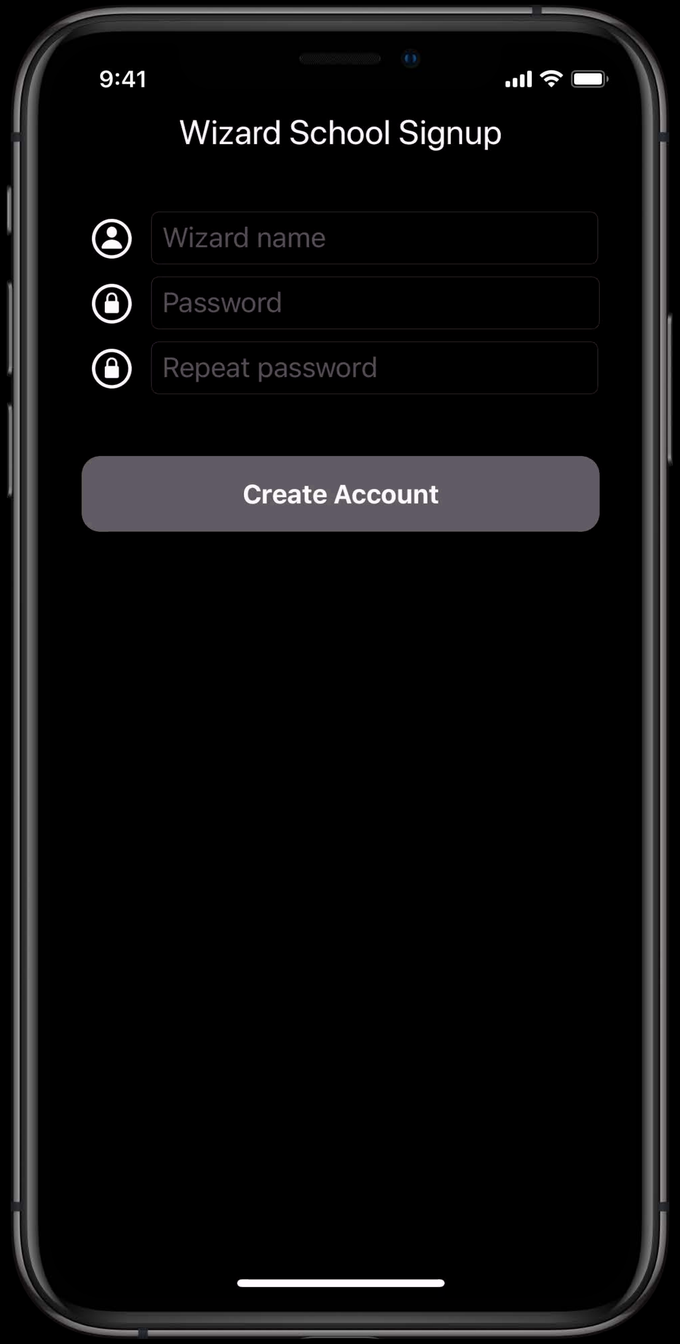
Wizard name
Password
Repeat password
Create Account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Password
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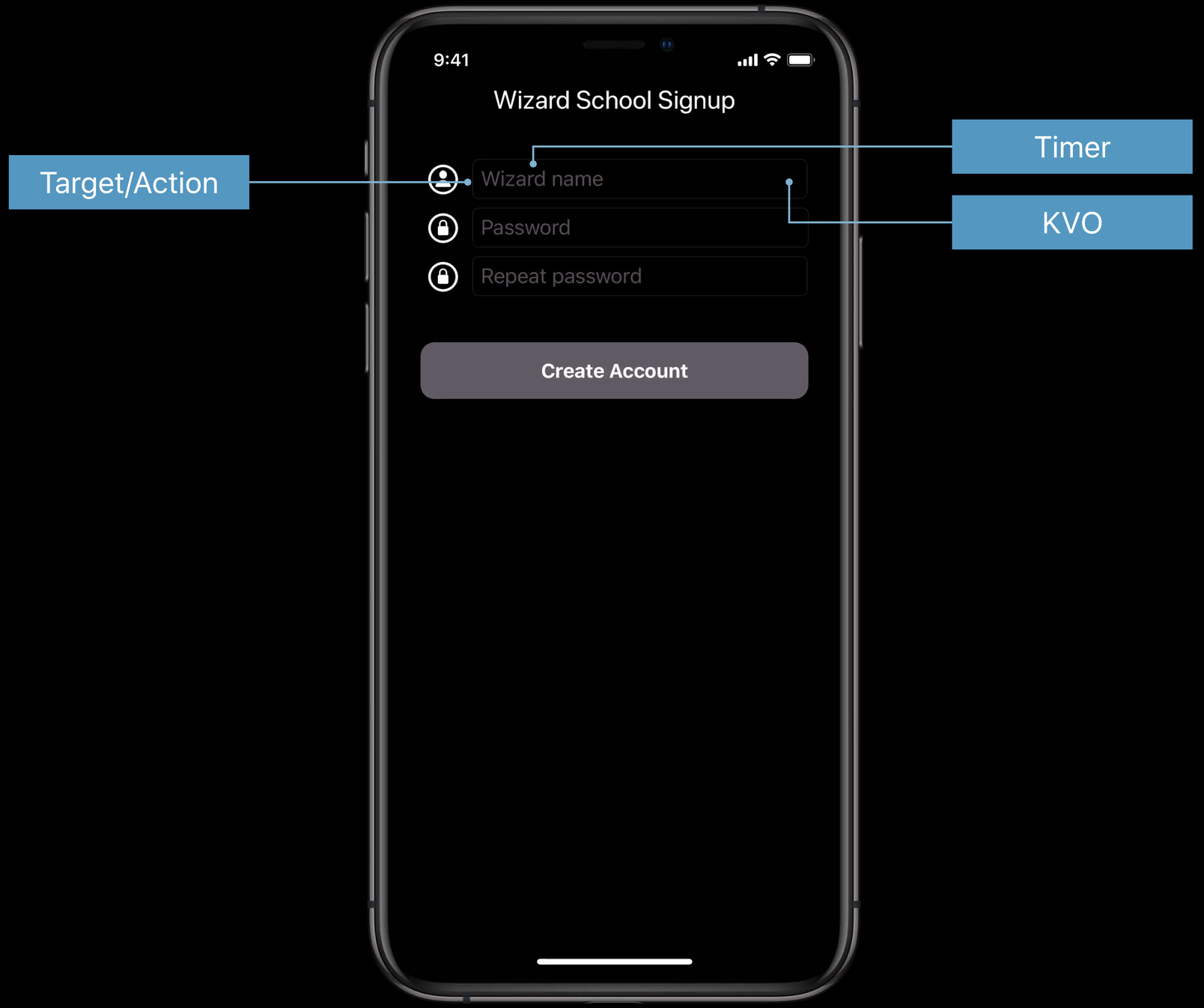
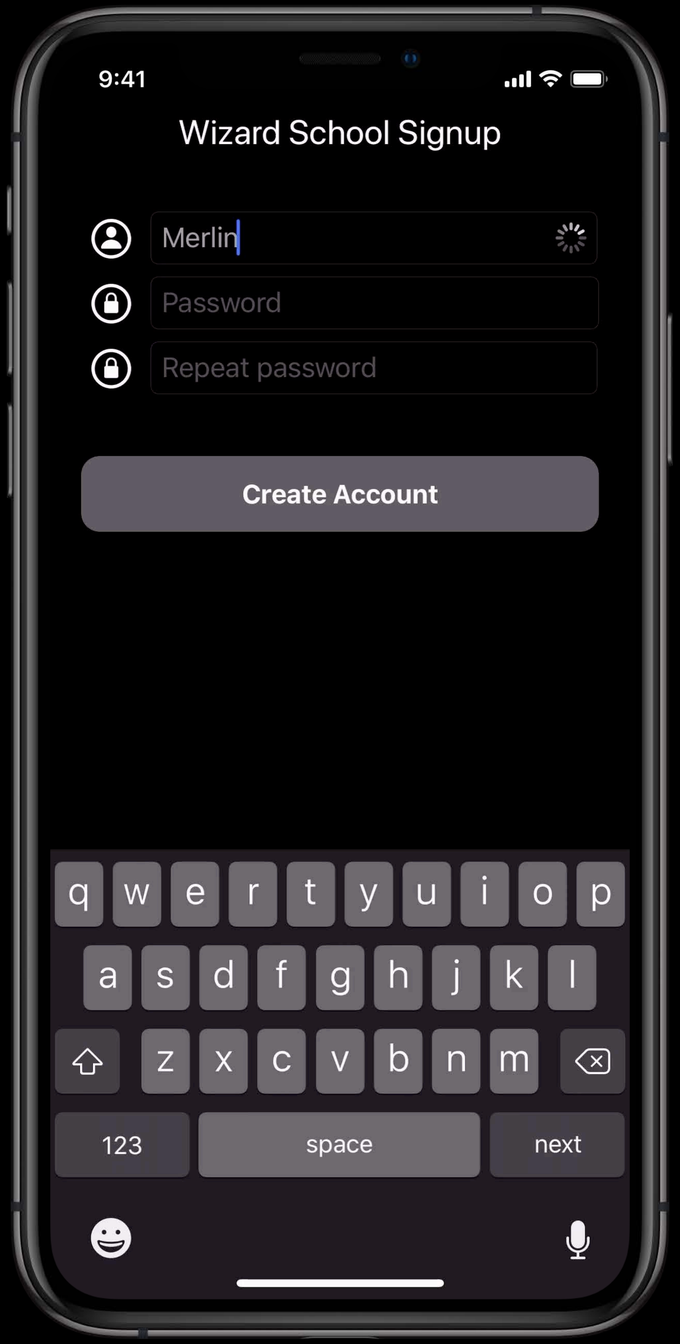

9:41
Wizard School Signup
Wizard name
Password
Repeat password
Create Account
Target/Action
Timer
KVO


9:41
Wizard School Signup
Merlin
Password
Repeat password
Create Account
q w e r t y u i o p
a s d f g h j k l
z x c v b n m
123
space
next


URLSession
9:41
Wizard School Signup
Merlin
Password
Repeat password
Create Account
Merge
KVC
q w e r t y u i o p
a s d f g h j k l
z x c v b n m
123
space
next

Asynchronous Interfaces

Target/Action

Notification center

URLSession

Key-value observing

Ad-hoc callbacks

A unified, declarative API for processing values over time

Combine Features

Generic

Type safe

Composition first

Request driven

Key Concepts

Publishers

Subscribers

Operators

Publisher

Defines how values and errors are produced

Value type

Allows registration of a `Subscriber`

Publisher

```
protocol Publisher {
    associatedtype Output
    associatedtype Failure: Error

    func subscribe<S: Subscriber>(_ subscriber: S)
        where S.Input == Output, S.Failure == Failure
}
```

Publisher

NotificationCenter

```
extension NotificationCenter {
    struct Publisher: Combine.Publisher {
        typealias Output = Notification
        typealias Failure = Never
        init(center: NotificationCenter, name: Notification.Name, object: Any? = nil)
    }
}
```

Subscriber

Receives values and a completion

Reference type

Subscriber

```
protocol Subscriber {
    associatedtype Input
    associatedtype Failure: Error

    func receive(subscription: Subscription)
    func receive(_ input: Input) -> Subscribers.Demand
    func receive(completion: Subscribers.Completion<Failure>)
}
```

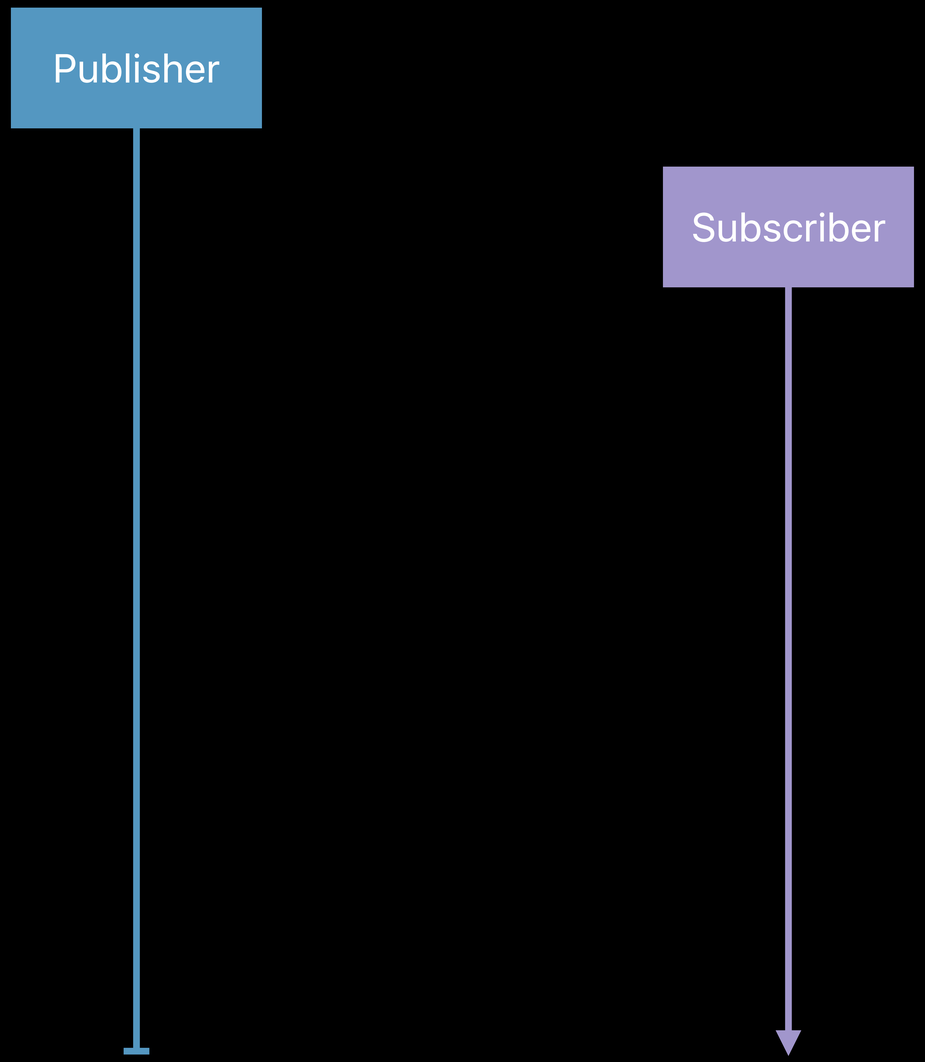
Subscriber

Assign

```
extension Subscribers {
    class Assign<Root, Input>: Subscriber, Cancellable {
        typealias Failure = Never
        init(object: Root, keyPath: ReferenceWritableKeyPath<Root, Input>)
    }
}
```

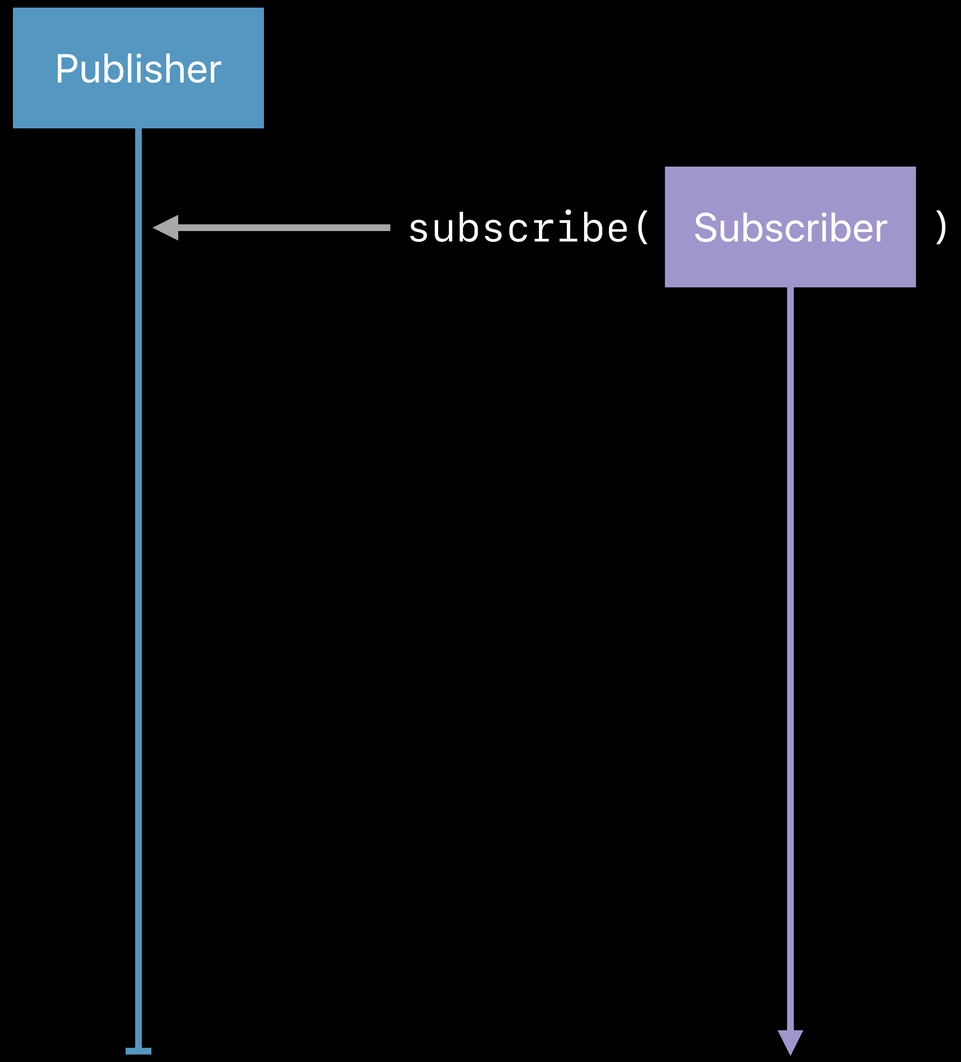
The Pattern

The Pattern



The Pattern

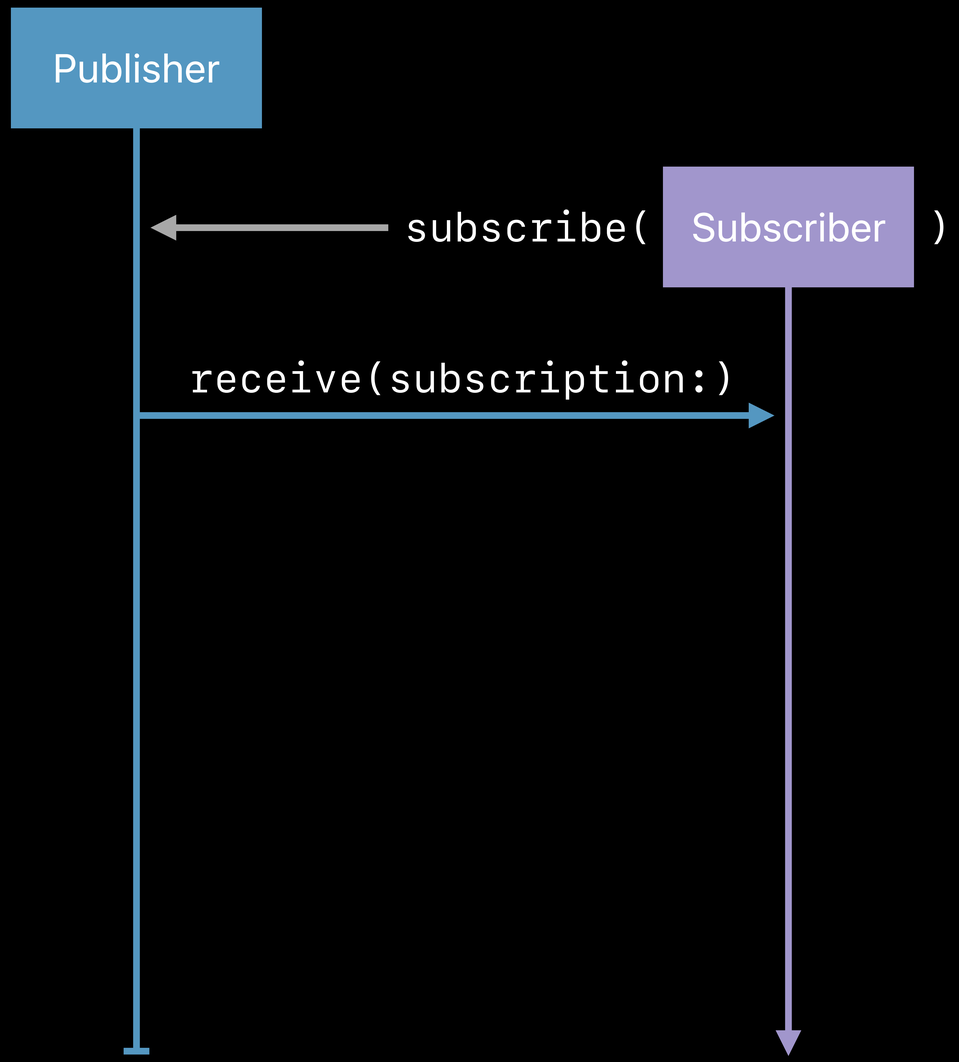
`Subscriber` is attached to `Publisher`



The Pattern

`Subscriber` is attached to `Publisher`

`Publisher` sends a `Subscription`

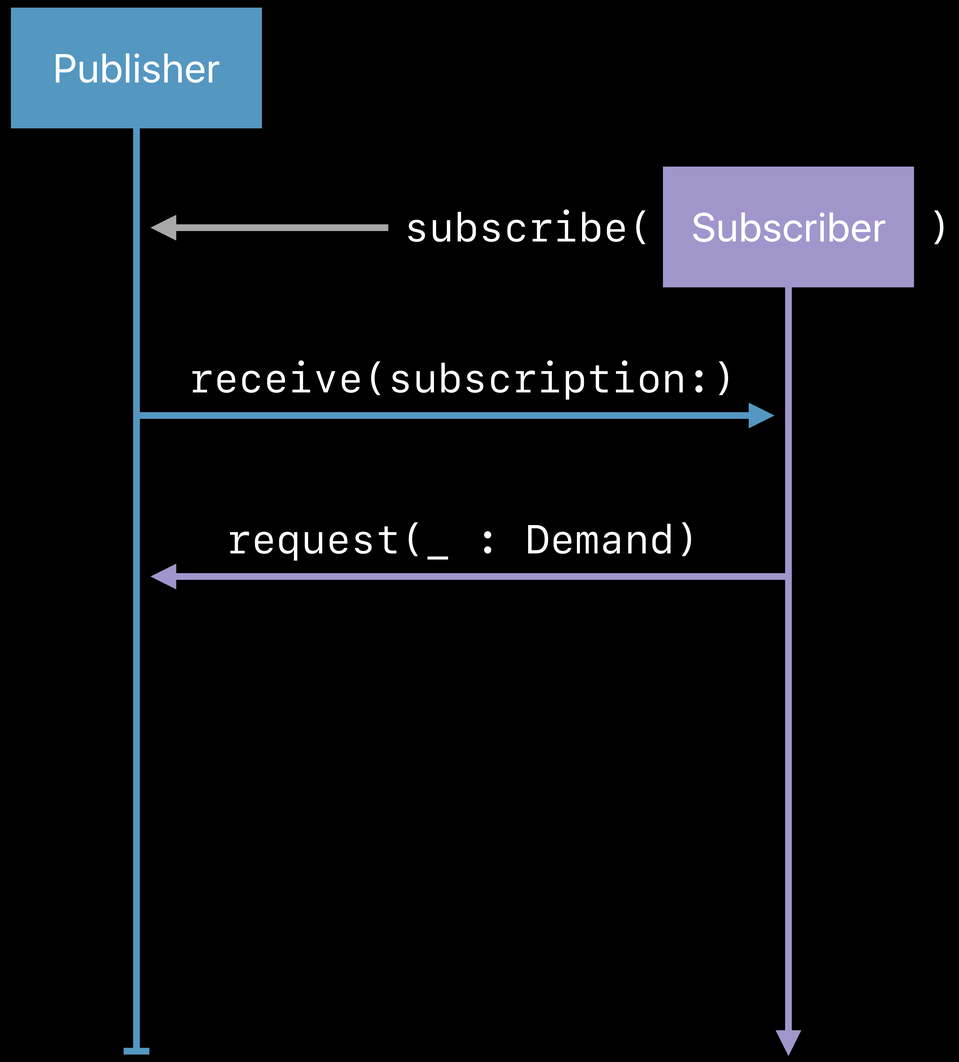


The Pattern

`Subscriber` is attached to `Publisher`

`Publisher` sends a `Subscription`

`Subscriber` requests *N* values



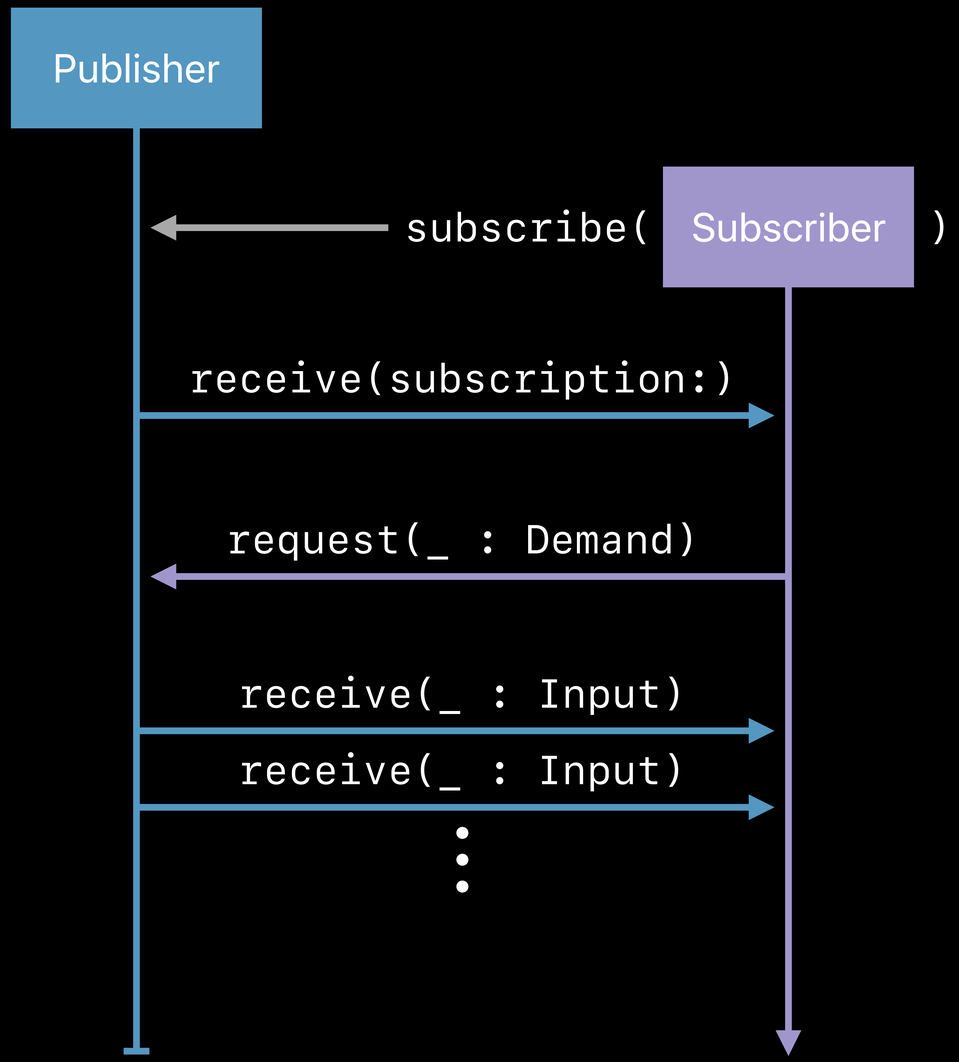
The Pattern

`Subscriber` is attached to `Publisher`

`Publisher` sends a `Subscription`

`Subscriber` requests *N* values

`Publisher` sends *N* values or less



The Pattern

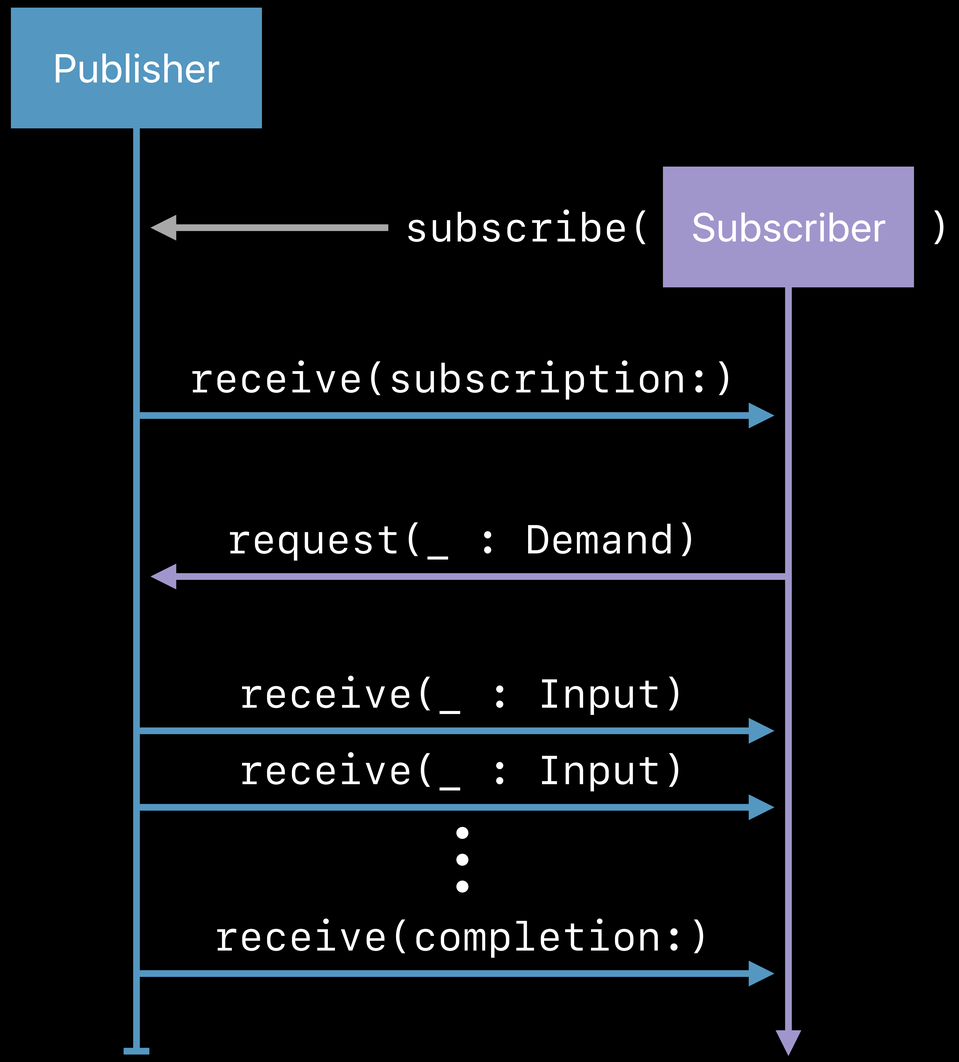
`Subscriber` is attached to `Publisher`

`Publisher` sends a `Subscription`

`Subscriber` requests *N* values

`Publisher` sends *N* values or less

`Publisher` sends completion



```swift
// Using Publisher and Subscriber
class Wizard {
    var grade: Int
}
let merlin = Wizard(grade: 5)

let graduationPublisher =
    NotificationCenter.Publisher(center: .default, name: .graduated, object: merlin)

let gradeSubscriber = Subscribers.Assign(object: merlin, keyPath: \.grade)


graduationPublisher.subscribe(gradeSubscriber)
```

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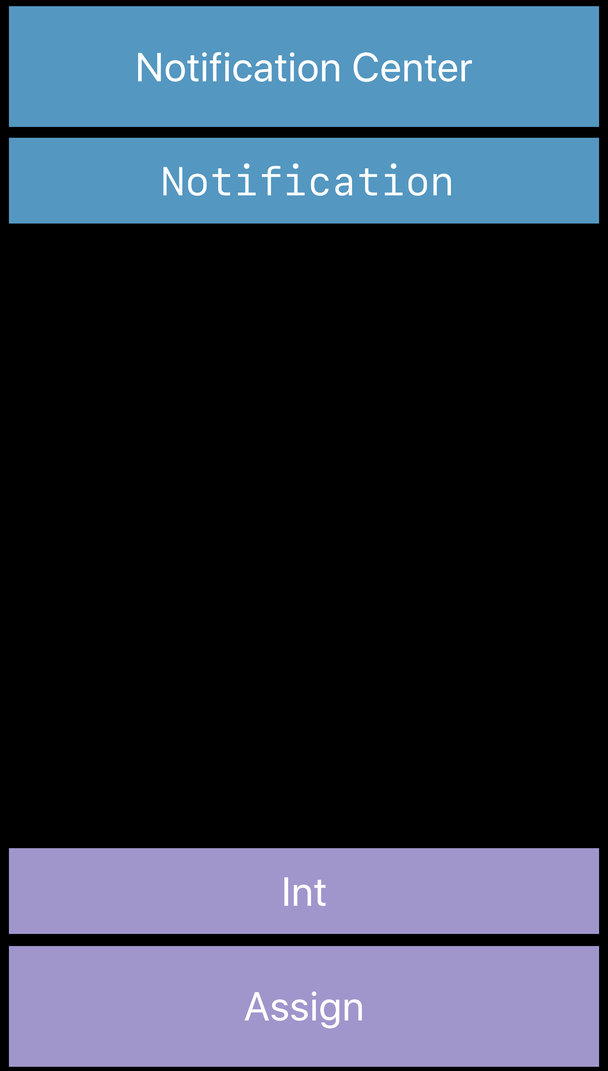
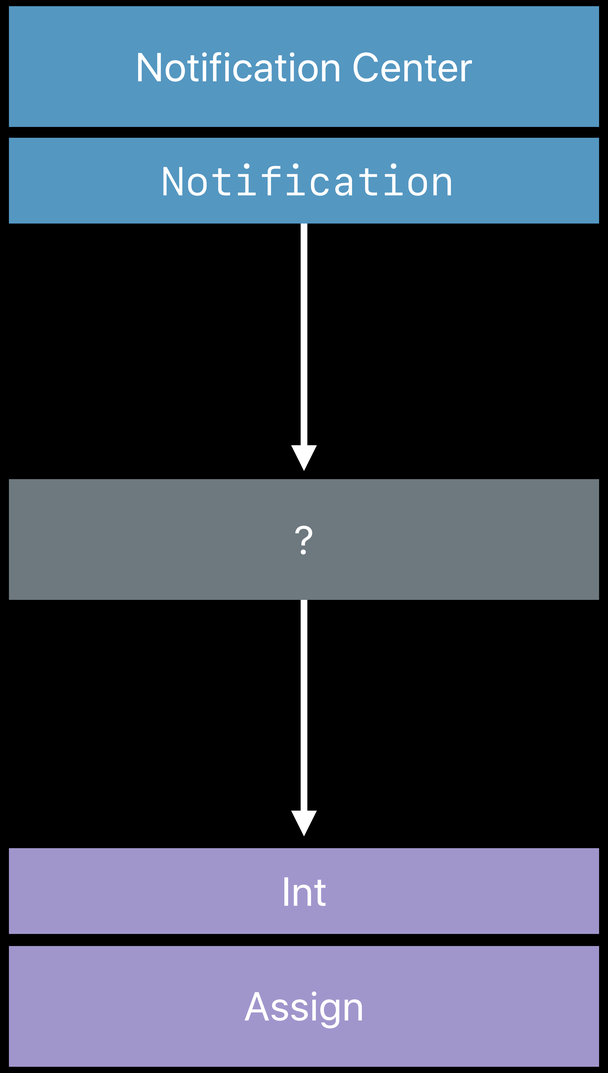
```

Instance method 'subscribe' requires the types 'NotificationCenter.Publisher.Output' (aka 'Notification') and 'Int' be equivalent


Notification Center
Notification
Int
Assign


Notification Center
Notification
?
Int
Assign

Operator

Adopts `Publisher`

Describes a behavior for changing values

Subscribes to a `Publisher` (“upstream”)

Sends result to a `Subscriber` (“downstream”)

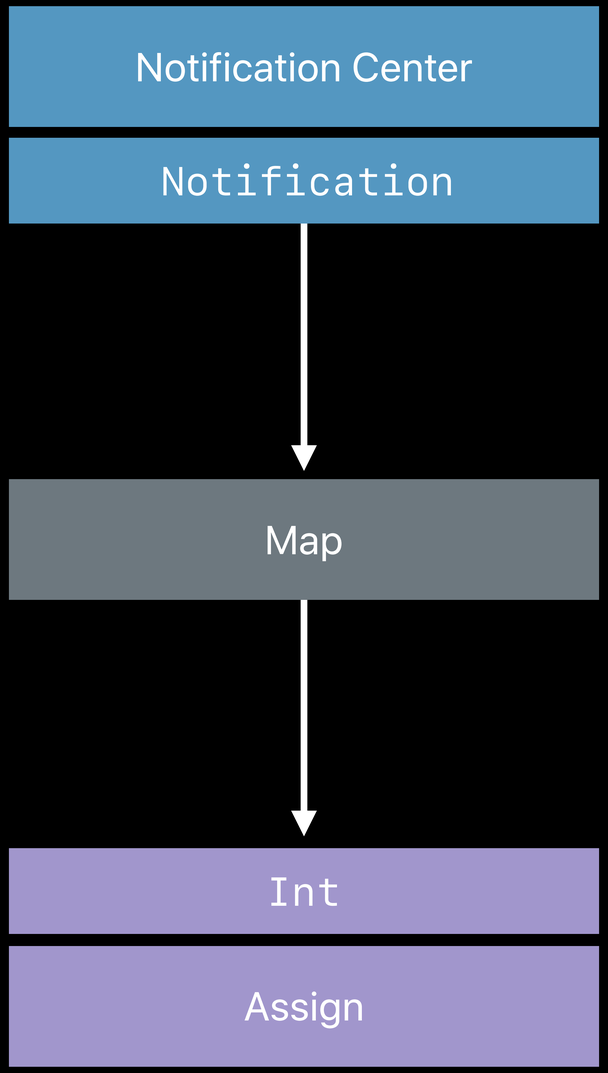
Value type

Operator

Map

```
extension Publishers {
    struct Map<Upstream: Publisher, Output>: Publisher {
        typealias Failure = Upstream.Failure

        let upstream: Upstream
        let transform: (Upstream.Output) -> Output
    }
}
```


Notification Center
Notification
Map
Int
Assign

```swift
// Using Operators
let graduationPublisher =
    NotificationCenter.Publisher(center: .default, name: .graduated, object: merlin)

let gradeSubscriber = Subscribers.Assign(object: merlin, keyPath: \.grade)


let converter = Publishers.Map(upstream: graduationPublisher) { note in
    return note.userInfo?["NewGrade"] as? Int ?? 0
}

converter.subscribe(gradeSubscriber)
```

```
// Using Operators
let graduationPublisher =
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}

converter.subscribe(gradeSubscriber)
```

```swift
// Operator Construction
extension Publisher {
    func map<T>(_ transform: @escaping (Output) -> T) -> Publishers.Map<Self, T> {
        return Publishers.Map(upstream: self, transform: transform)
    }
}
```

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// Operator Construction
extension Publisher {
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        return Publishers.Map(upstream: self, transform: transform)
    }
}
```

```
// Chained Publishers
let cancellable =
    NotificationCenter.default.publisher(for: .graduated, object: merlin)
        .map { note in
            return note.userInfo?["NewGrade"] as? Int ?? 0
        }
        .assign(to: \.grade, on: merlin)
```

```
// Chained Publishers
let cancellable =
    NotificationCenter.default.publisher(for: .graduated, object: merlin)
        .map { note in
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        }
        .assign(to: \.grade, on: merlin)
```

```
// Chained Publishers
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        }
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```

```
// Chained Publishers
let cancellable =
    NotificationCenter.default.publisher(for: .graduated, object: merlin)
        .map { note in
            return note.userInfo?["NewGrade"] as? Int ?? 0
        }
        .assign(to: \.grade, on: merlin)
```

Declarative Operator API

Functional transformations

List operations

Error handling

Thread or queue movement

Scheduling and time

catch append count first min

dropFirst **map** abortOnError **merge** log last

allSatisfy filter breakpointOnError handleEvents mapError output

breakpoint **flatMap** ignoreOutput max **drop** prefix

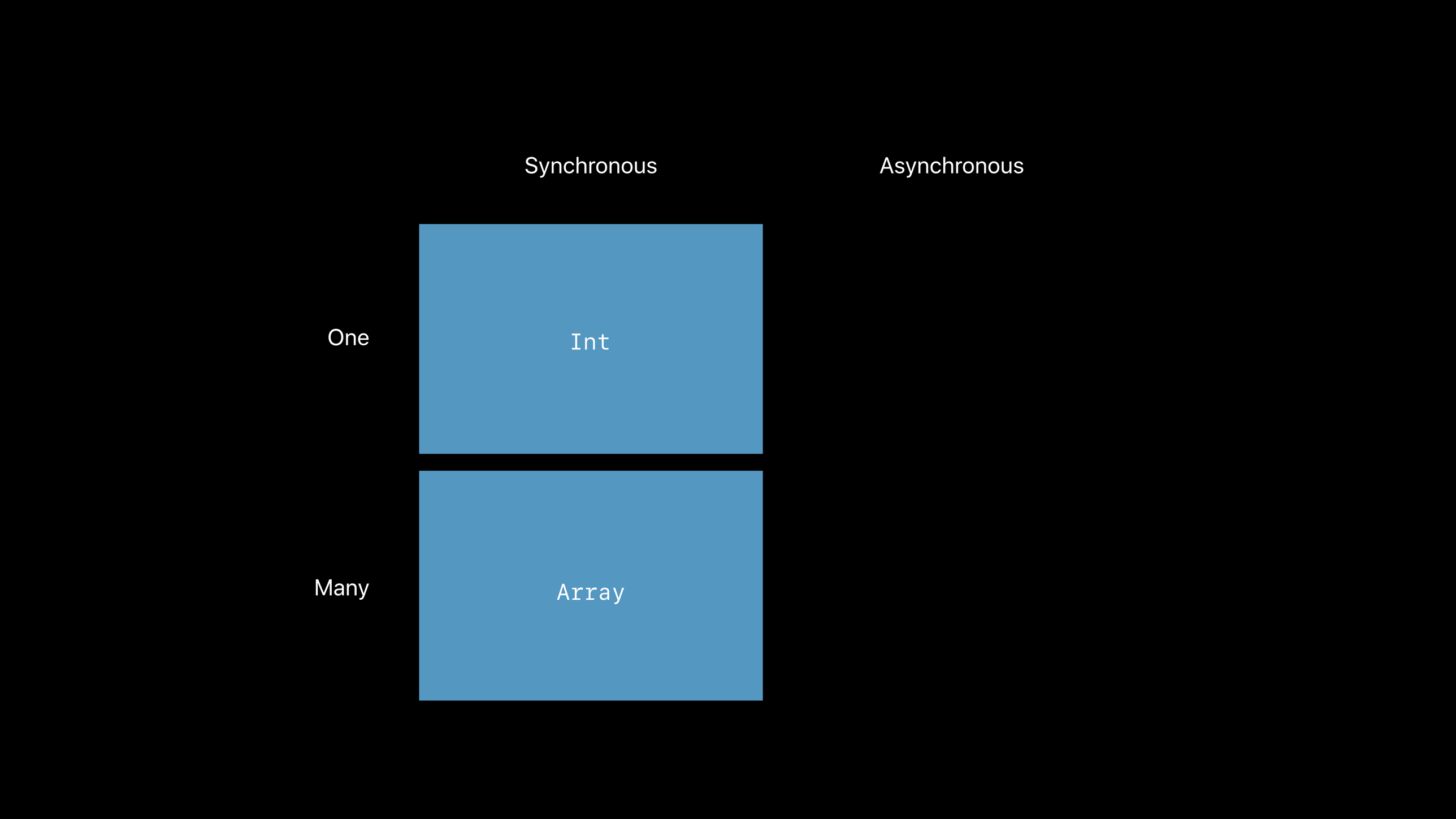
setFailureType removeDuplicates **reduce** combineLatest replaceEmpty

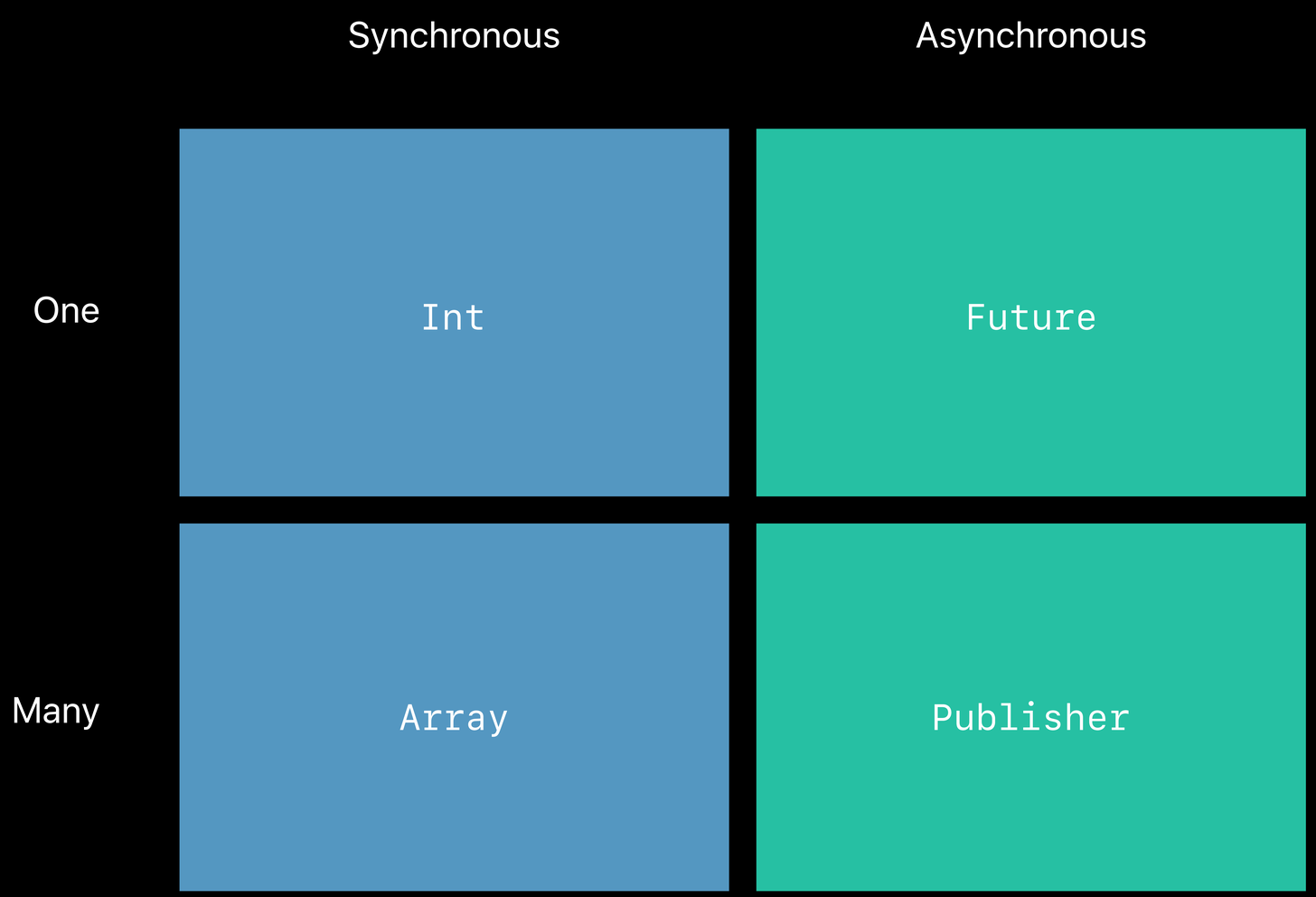
prepend **contains** switchToLatest **collect** compactMap

replaceError replaceNil scan retry print zip

Try composition first

	Synchronous	Asynchronous
One		
Many		


Synchronous
Asynchronous
One
Many
Int
Array


Synchronous
Asynchronous
One
Many
Int
Future
Array
Publisher

```
// Composing Operators
let cancellable =
    NotificationCenter.default.publisher(for: .graduated, object: merlin)
        .map { note in
            return note.userInfo?["NewGrade"] as? Int ?? 0
        }
        .assign(to: \.grade, on: merlin)
```

```
// Composing Operators
let cancellable =
    NotificationCenter.default.publisher(for: .graduated, object: merlin)
        .map { note in
            return note.userInfo?["NewGrade"] as? Int ?? 0
        }
        .assign(to: \.grade, on: merlin)
```

```
// Composing Operators
let cancellable =
    NotificationCenter.default.publisher(for: .graduated, object: merlin)
        .compactMap { note in
            return note.userInfo?["NewGrade"] as? Int
        }
        .assign(to: \.grade, on: merlin)
```

```
// Composing Operators
let cancellable =
    NotificationCenter.default.publisher(for: .graduated, object: merlin)
        .compactMap { note in
            return note.userInfo?["NewGrade"] as? Int
        }
        .filter { $0 >= 5 }
        .assign(to: \.grade, on: merlin)
```

```
// Composing Operators
let cancellable =
    NotificationCenter.default.publisher(for: .graduated, object: merlin)
        .compactMap { note in
            return note.userInfo?["NewGrade"] as? Int
        }
        .filter { $0 >= 5 }
        .assign(to: \.grade, on: merlin)
```

```
// Composing Operators
let cancellable =
    NotificationCenter.default.publisher(for: .graduated, object: merlin)
        .compactMap { note in
            return note.userInfo?["NewGrade"] as? Int
        }
        .filter { $0 >= 5 }
        .prefix(3)
        .assign(to: \.grade, on: merlin)
```

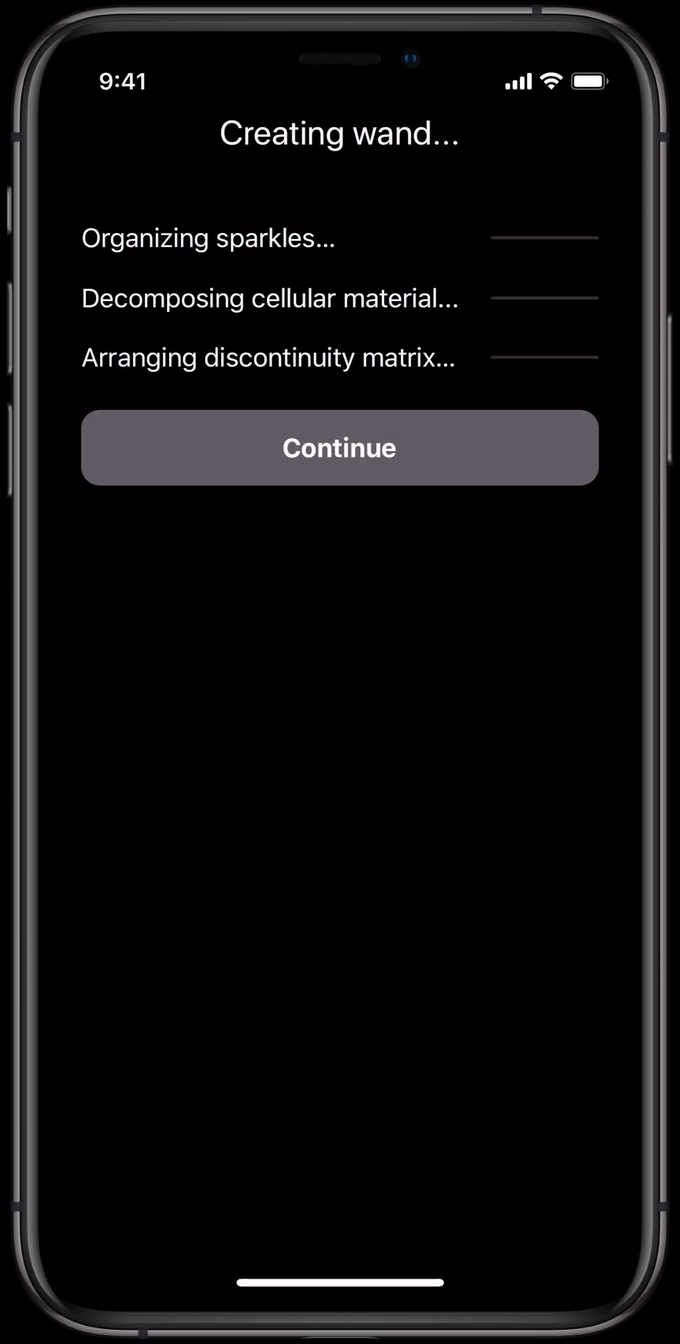
```
// Composing Operators
let cancellable =
    NotificationCenter.default.publisher(for: .graduated, object: merlin)
        .compactMap { note in
            return note.userInfo?["NewGrade"] as? Int
        }
        .filter { $0 >= 5 }
        .prefix(3)
        .assign(to: \.grade, on: merlin)
```

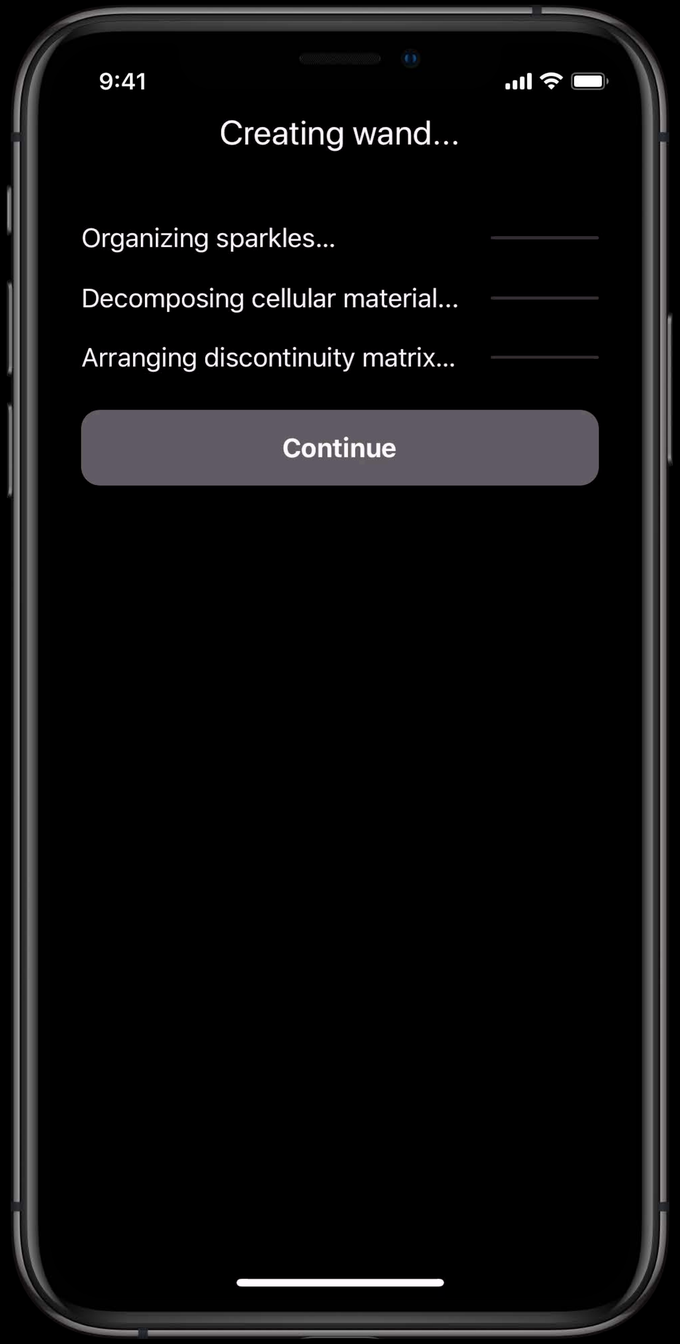
```
// Composing Operators
let cancellable =
    NotificationCenter.default.publisher(for: .graduated, object: merlin)
        .compactMap { note in
            return note.userInfo?["NewGrade"] as? Int
        }
        .filter { $0 >= 5 }
        .prefix(3)
        .assign(to: \.grade, on: merlin)
```

Combining Publishers

Zip

CombineLatest


9:41
Creating wand...
Organizing sparkles...
Decomposing cellular material...
Arranging discontinuity matrix...
Continue

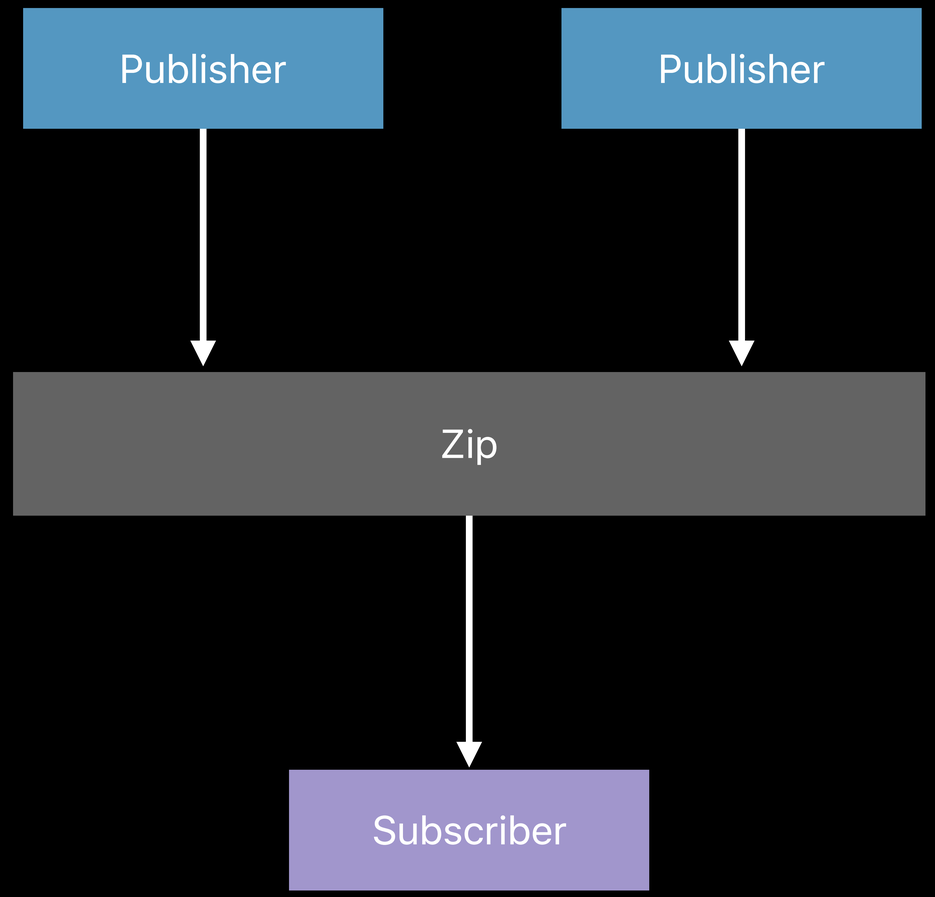

9:41
Creating wand...
Organizing sparkles...
Decomposing cellular material...
Arranging discontinuity matrix...
Continue

Zip

Converts several inputs into a single tuple

A “when/and” operation

Requires input from all to proceed

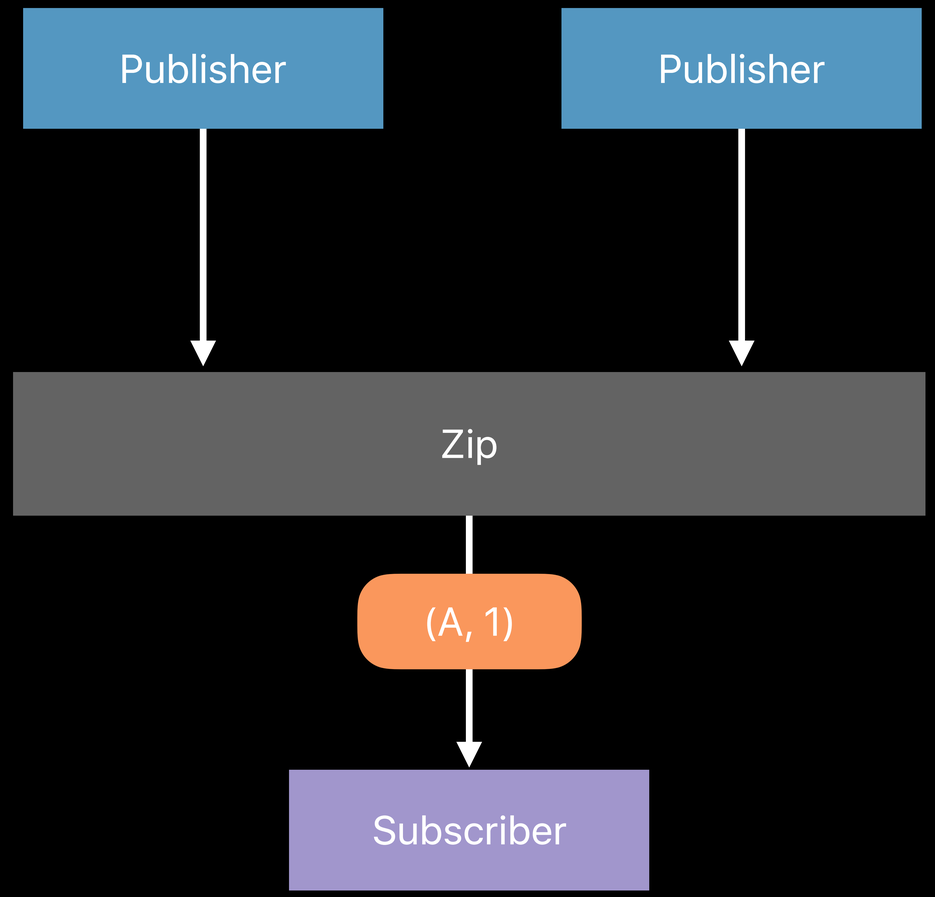


Zip

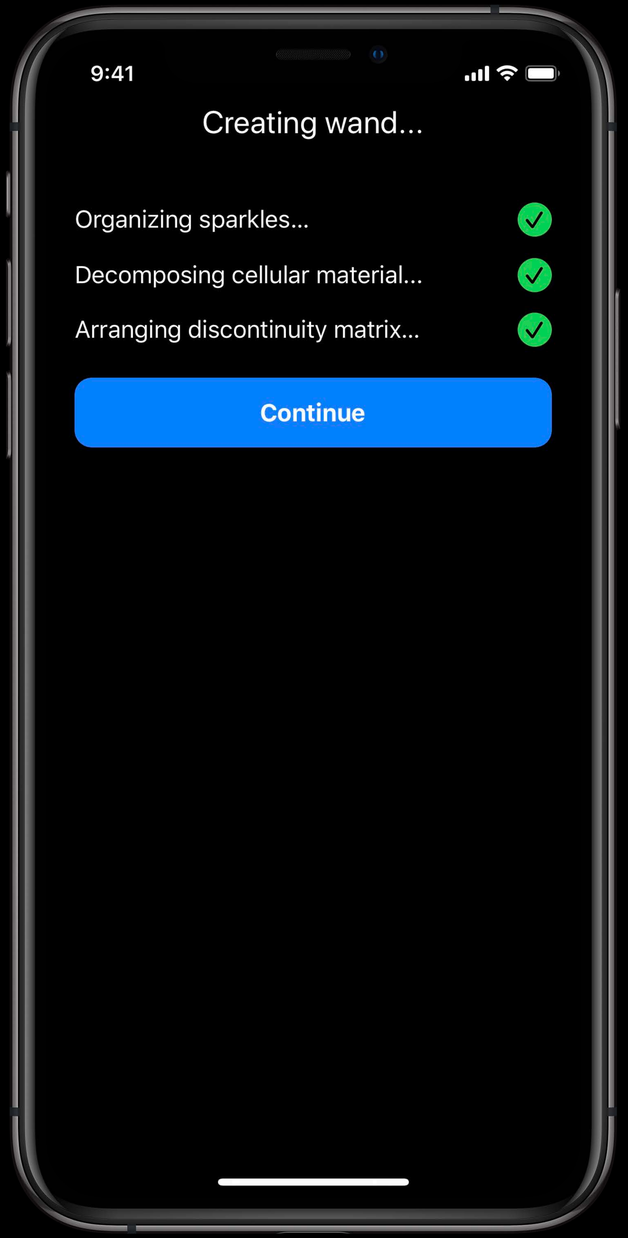
Converts several inputs into a single tuple

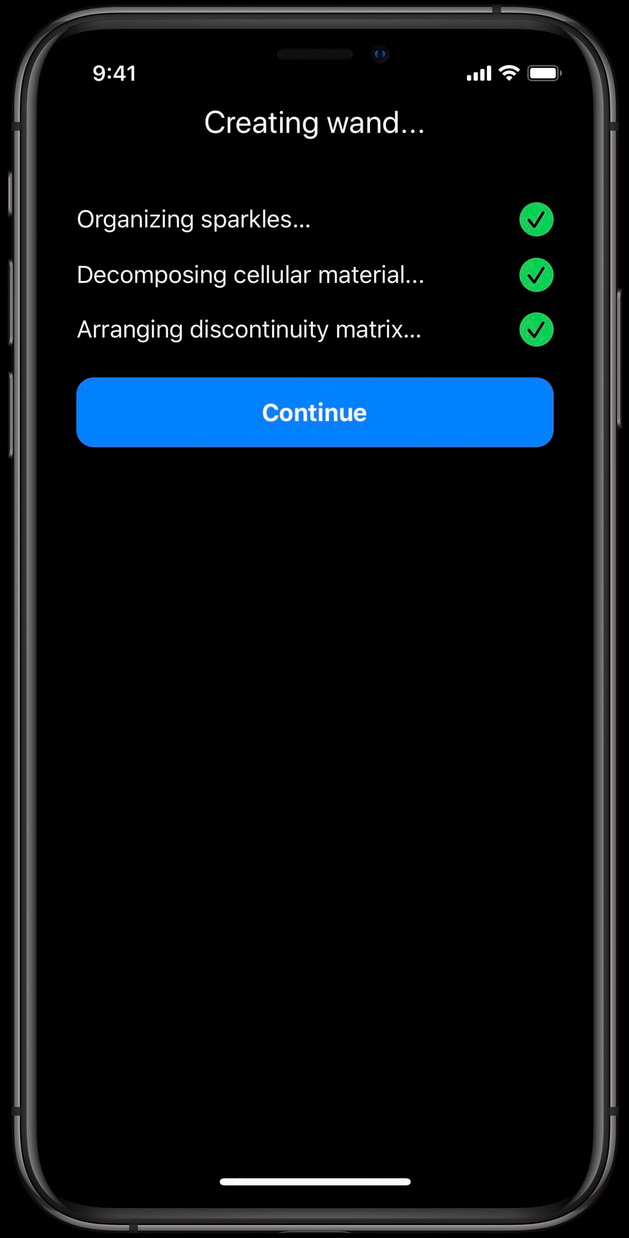
A “when/and” operation

Requires input from all to proceed



```
Zip3(organizing, decomposing, arranging)
    .map { $0 && $1 && $2 }
    .assign(to: \.isEnabled, on: continueButton)
```

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Organizing sparkles...
Decomposing cellular material...
Arranging discontinuity matrix...
Continue


9:41
Terms & Conditions
Read manual
Practiced in simulator
Teacher approved
Play


9:41
Terms & Conditions
Read manual
Practiced in simulator
Teacher approved
Play

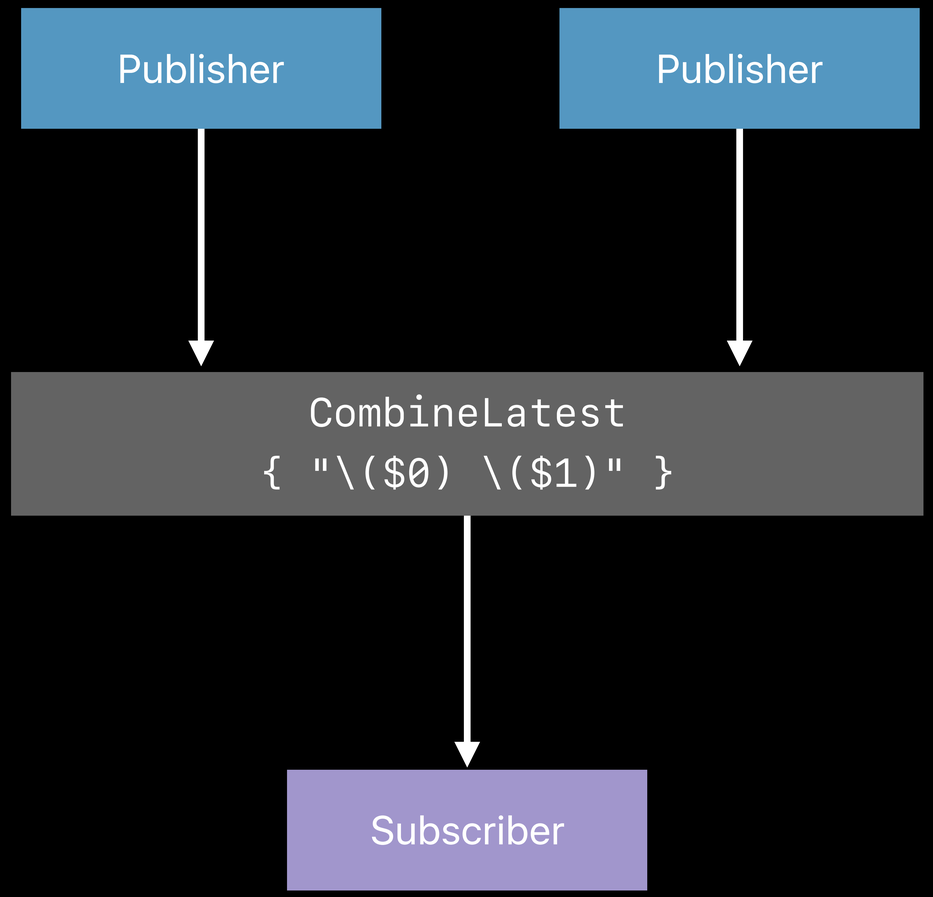
Combine Latest

Converts several inputs into a single value

A “when/or” operation

Requires input from any to proceed

Stores last value



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A “when/or” operation

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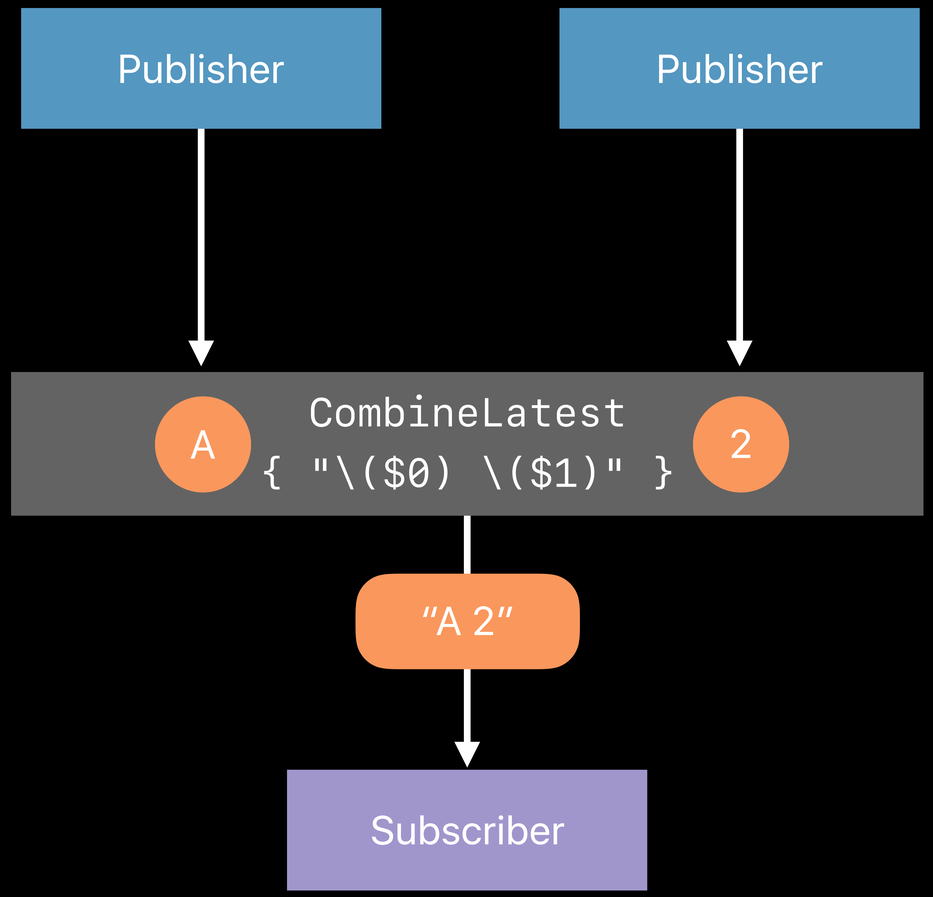
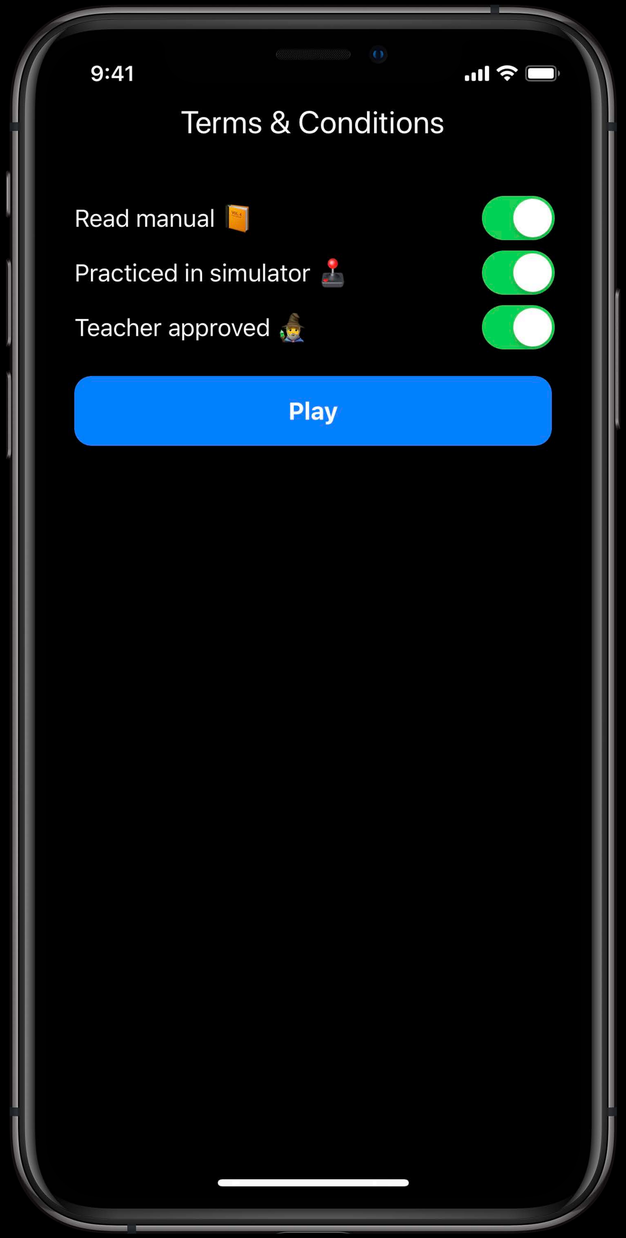


```
CombineLatest3(read, practiced, approved) {
    $0 && $1 && $2
}
.assign(to: \.isEnabled, on: playButton)
```



Try It

Process a `NotificationCenter` post with `filter`

Await completion of two network requests with `zip`

`decode` the data of a `URLResponse`

More to Combine

Error handling and cancellation

Schedulers and time

Design patterns

Combine in Practice — Thursday, 2:00

More Information

developer.apple.com/wwdc19/722


WWDC19