#WWDC19

Making Apps with Core Data

Scott Perry, Core Data Engineer

Getting started

The needs of the Controller

Scaling your app

Testing

Getting started

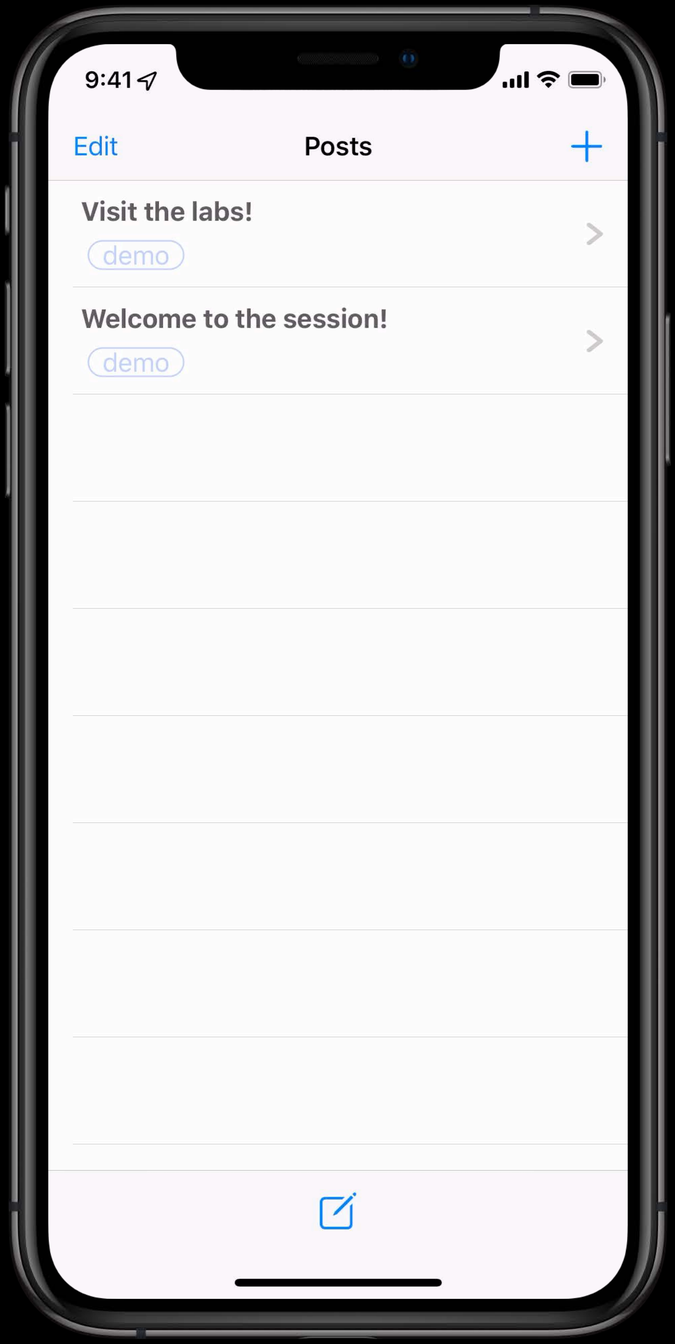
The needs of the Controller

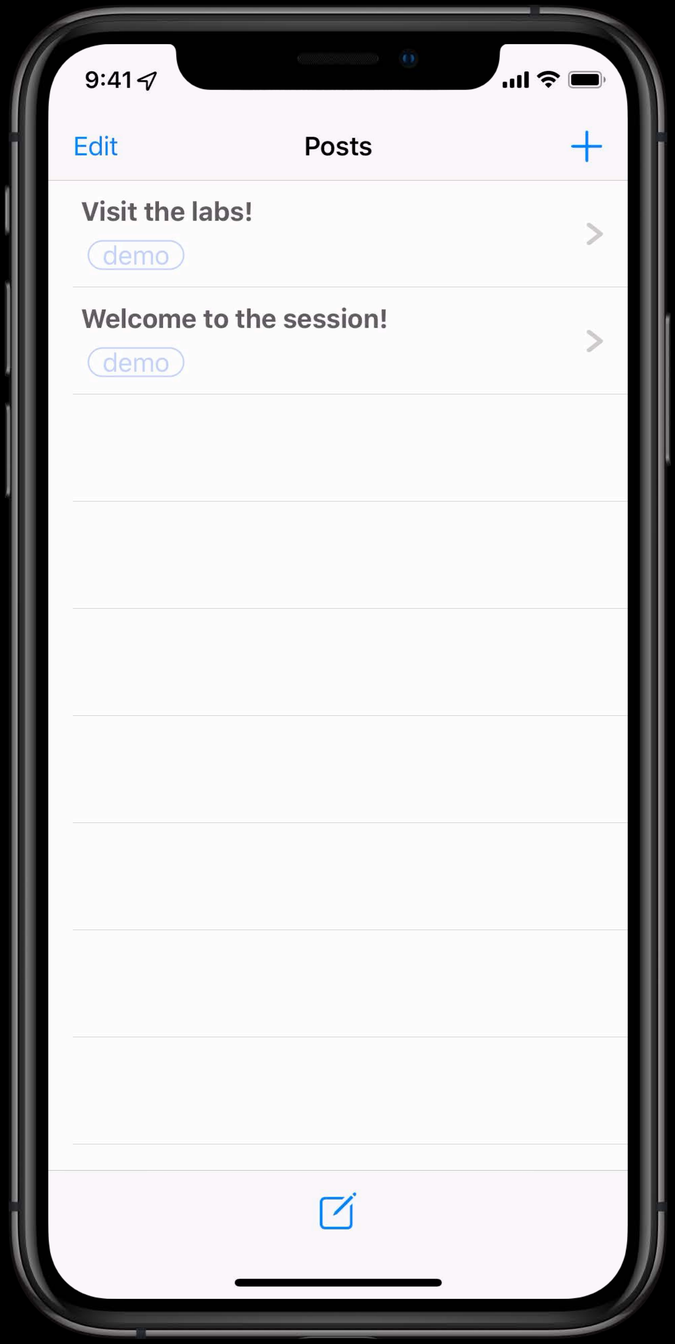
Scaling your app

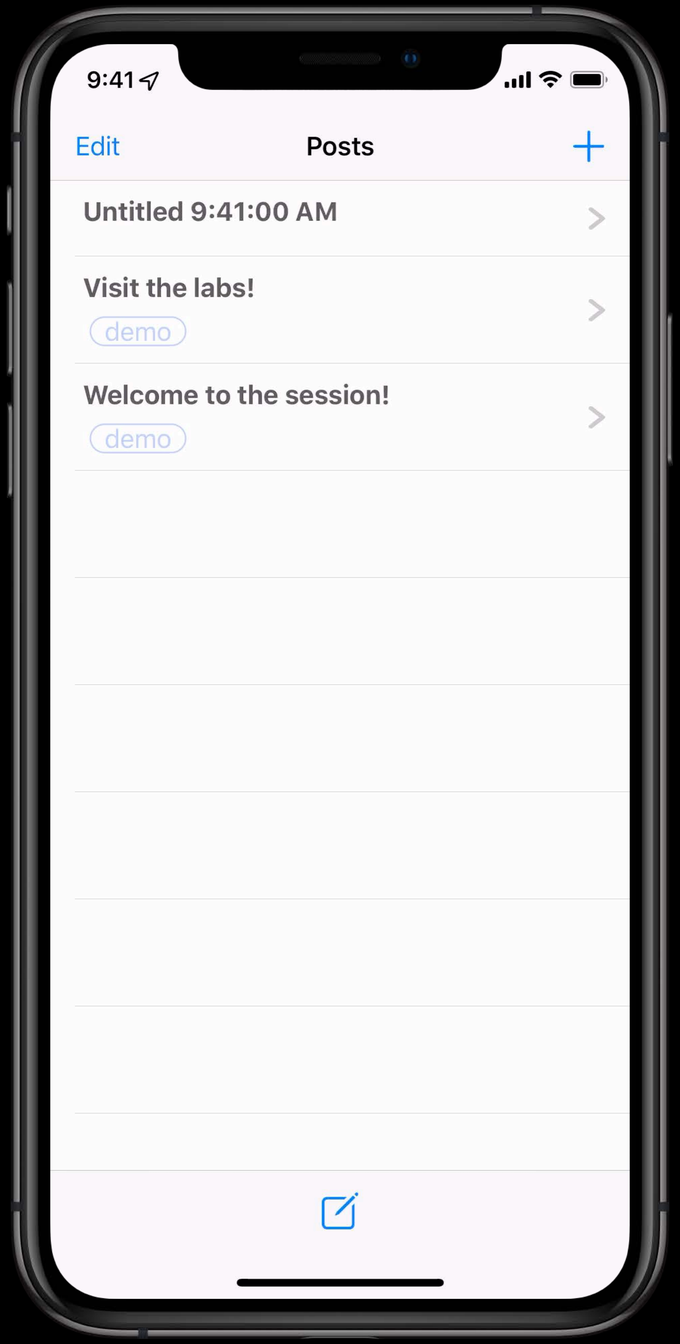
Testing

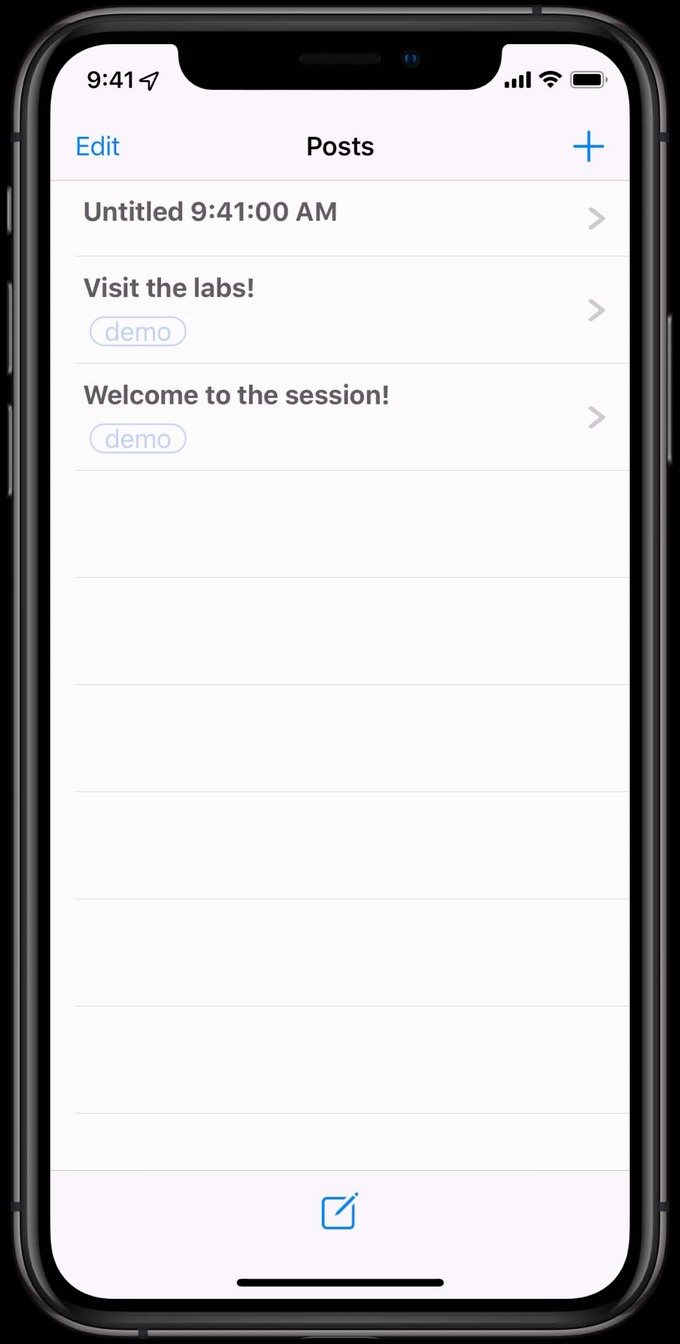

9:41
FaceTime
Monday
3
Calendar
Photos
Camera
Mail
Clock
Maps
280
Weather
Reminders
Notes
Stocks
News
Books
App Store
Podcasts
tv
TV
Health
Home
Wallet
CoreDataCloudKit(

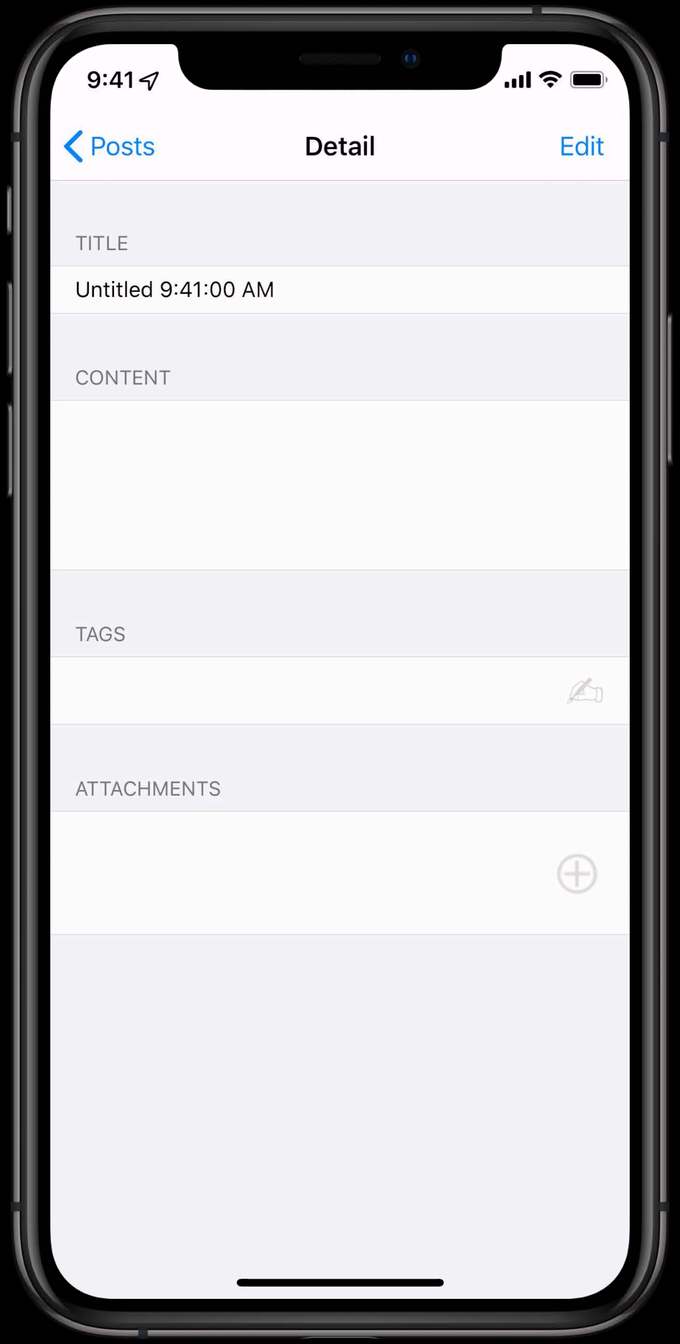

9:41
FaceTime
Monday
3
Calendar
Photos
Camera
Mail
Clock
Maps
280
Weather
Reminders
Notes
Stocks
News
Books
App Store
Podcasts
tv
TV
Health
Home
Wallet
CoreDataCloudKit(

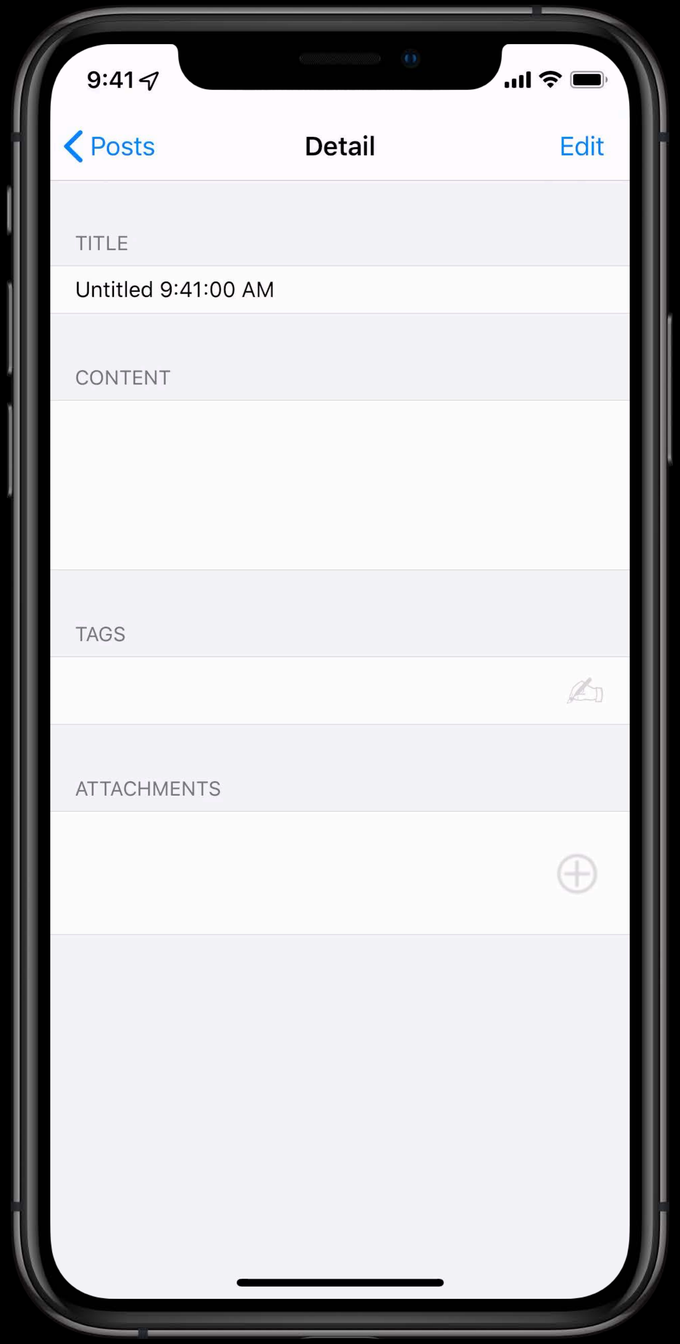

9:41
Edit
Posts
Visit the labs!
demo
Welcome to the session!
demo

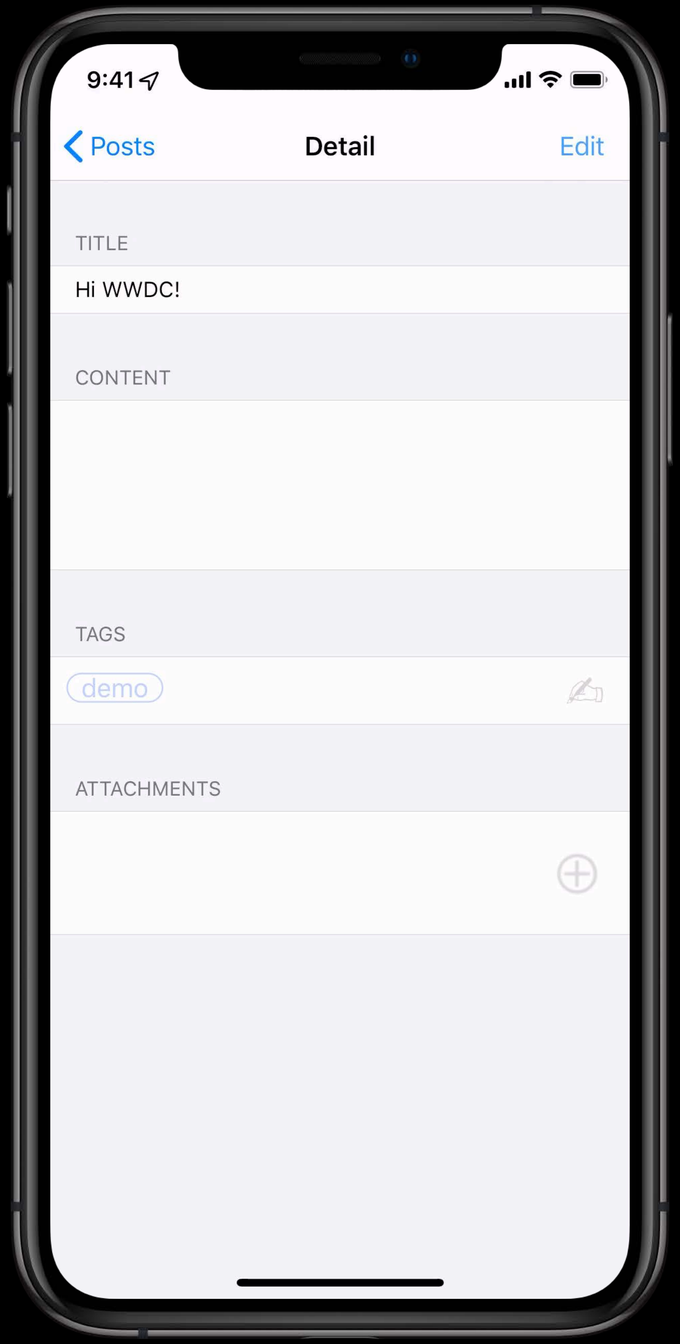

9:41
Edit
Posts
Visit the labs!
demo
Welcome to the session!
demo

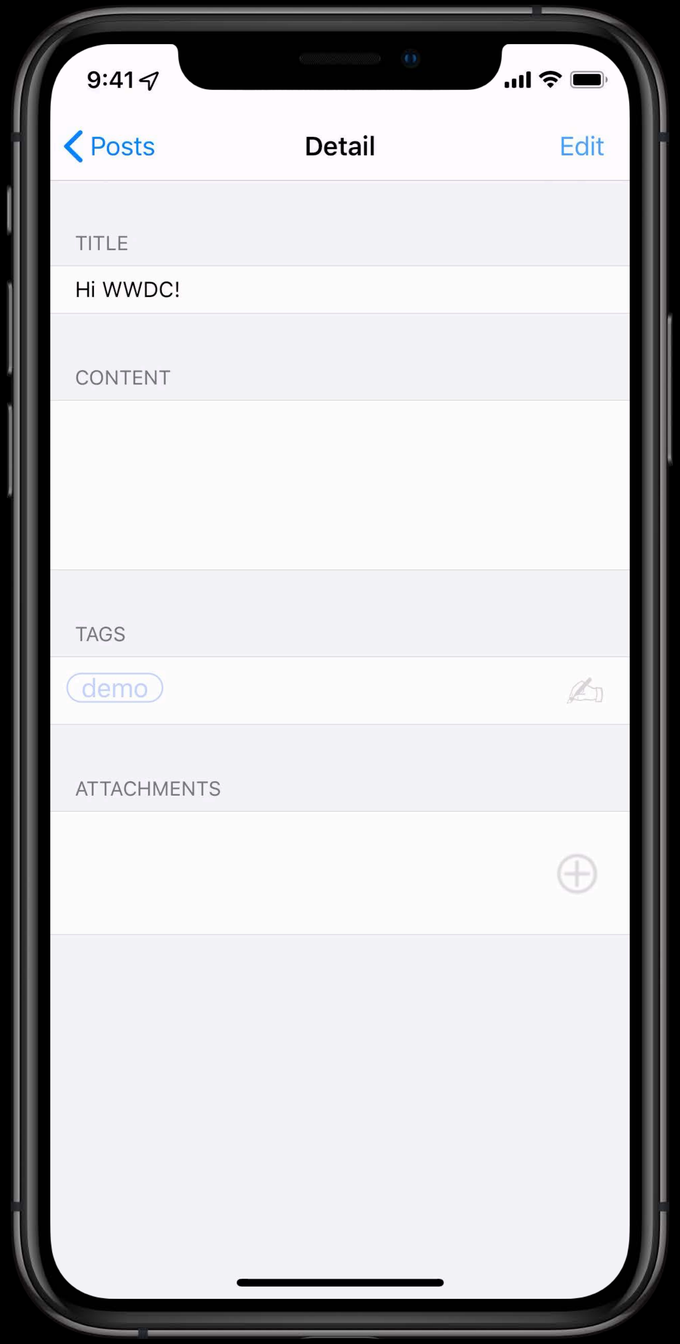

9:41
Edit
Posts
Untitled 9:41:00 AM
Visit the labs!
demo
Welcome to the session!
demo

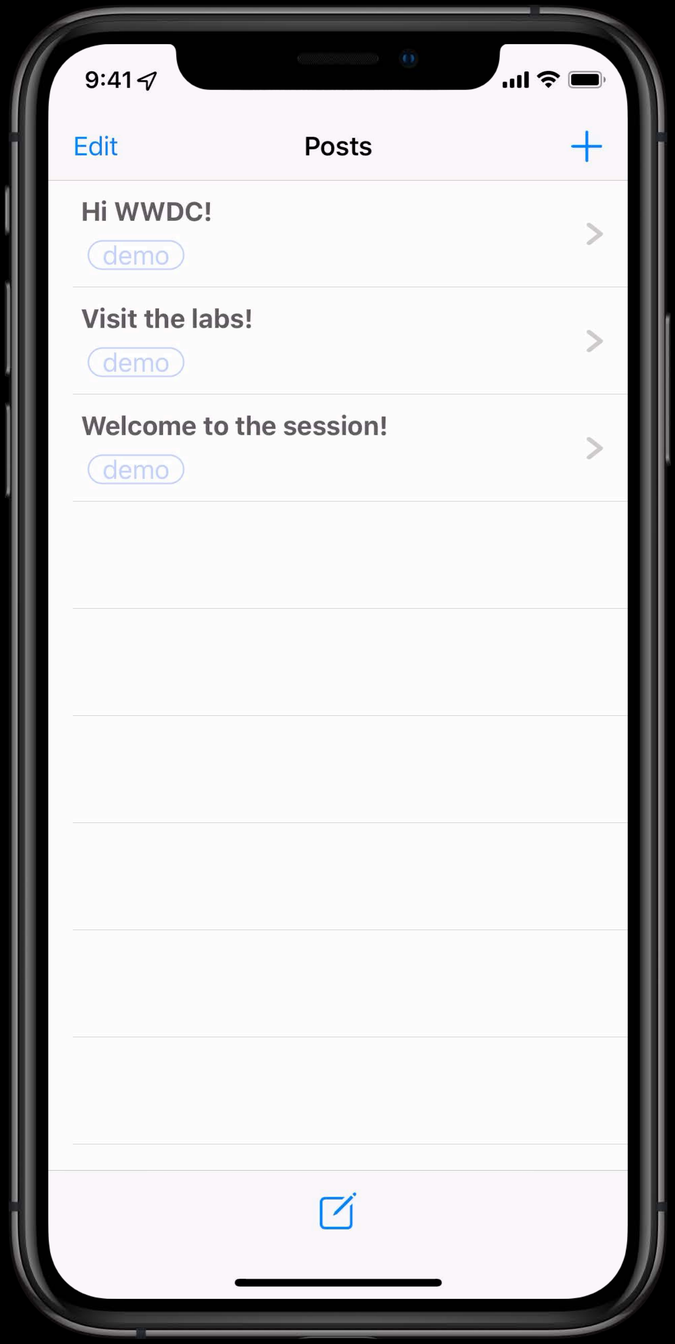

9:41
Edit
Posts
Untitled 9:41:00 AM
Visit the labs!
demo
Welcome to the session!
demo

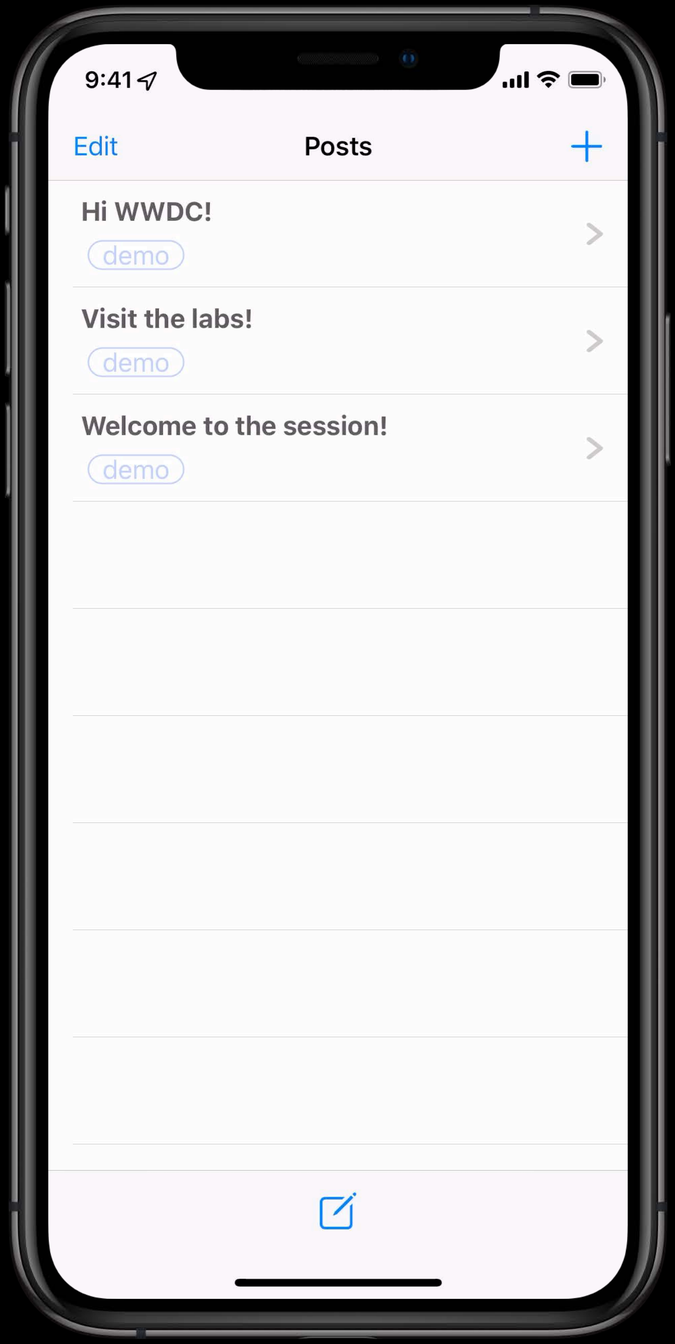

9:41
Posts
Detail
Edit
TITLE
Untitled 9:41:00 AM
CONTENT
TAGS
ATTACHMENTS

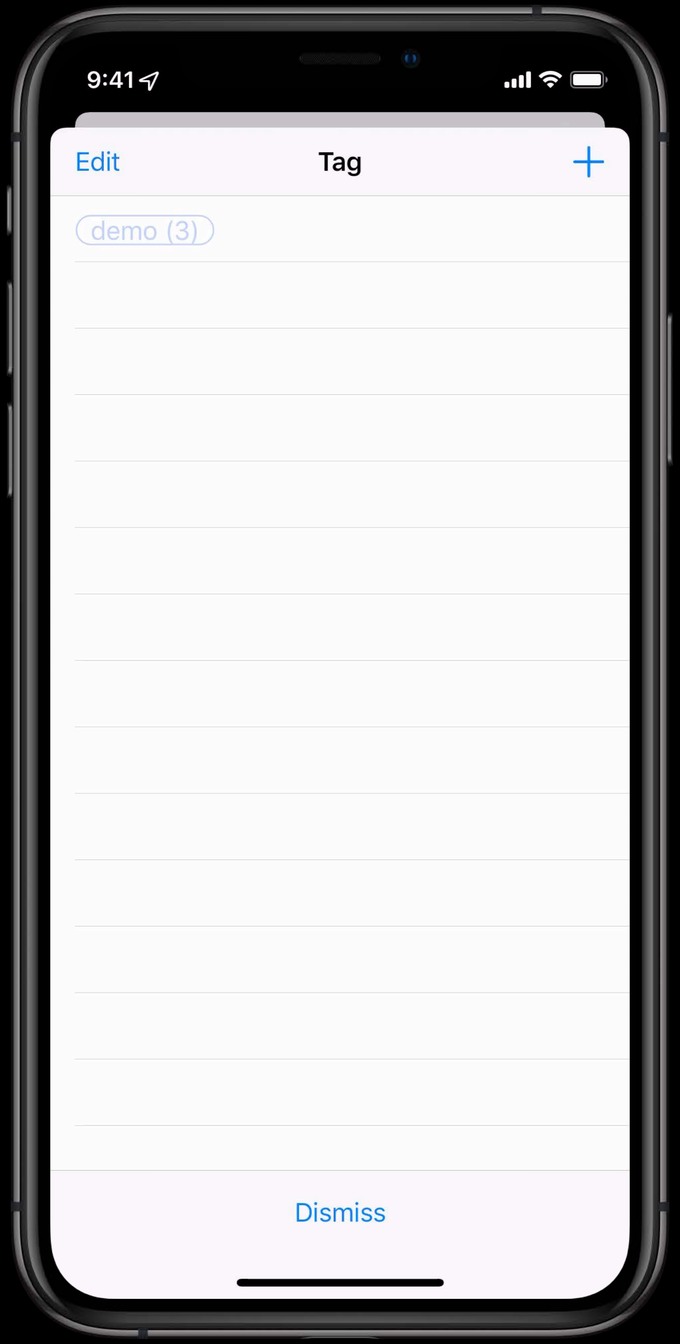

9:41
Posts
Detail
Edit
TITLE
Untitled 9:41:00 AM
CONTENT
TAGS
ATTACHMENTS

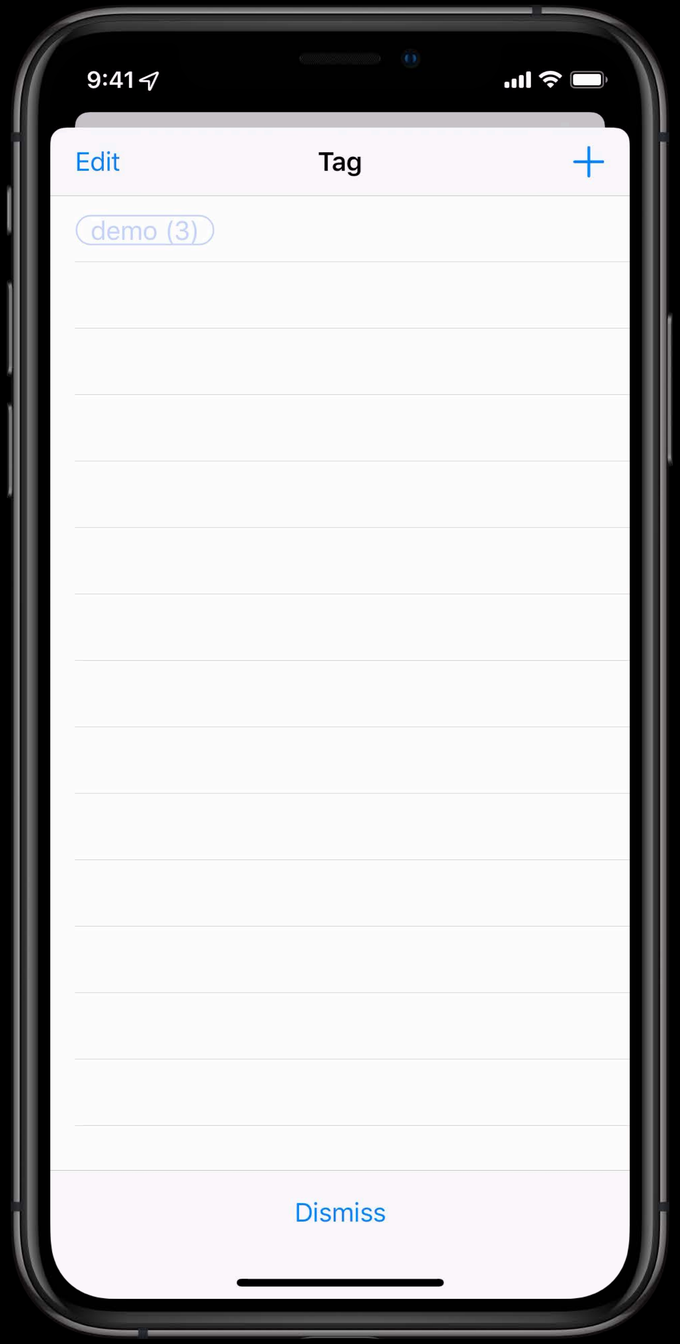

9:41
Posts
Detail
Edit
TITLE
Hi WWDC!
CONTENT
TAGS
demo
ATTACHMENTS

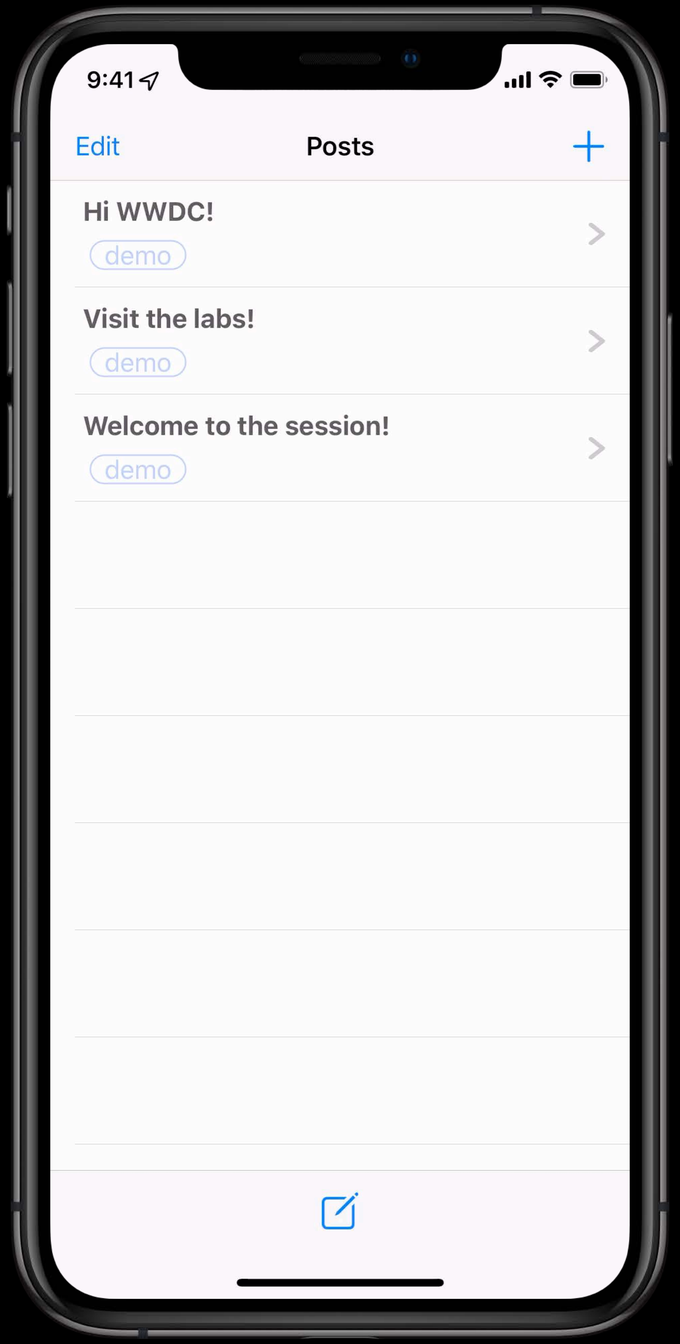

9:41
Posts
Detail
Edit
TITLE
Hi WWDC!
CONTENT
TAGS
demo
ATTACHMENTS

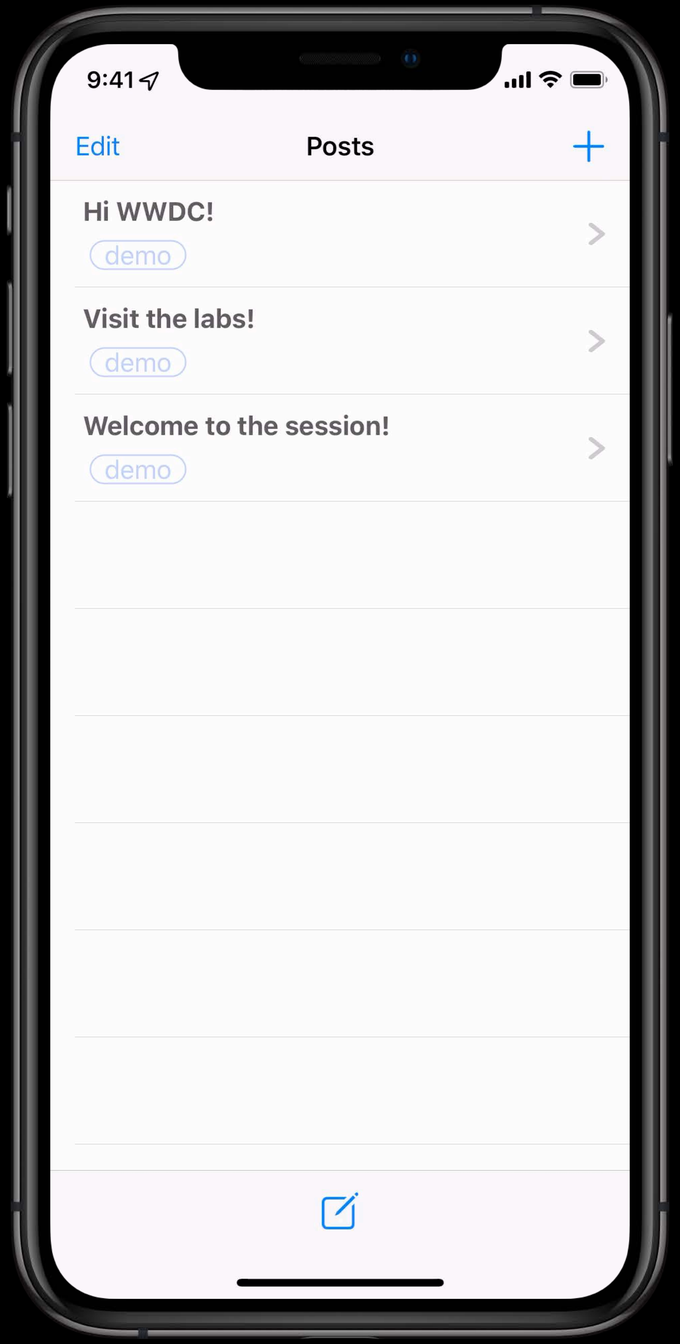

9:41
Edit
Posts
Hi WWDC!
demo
Visit the labs!
demo
Welcome to the session!
demo

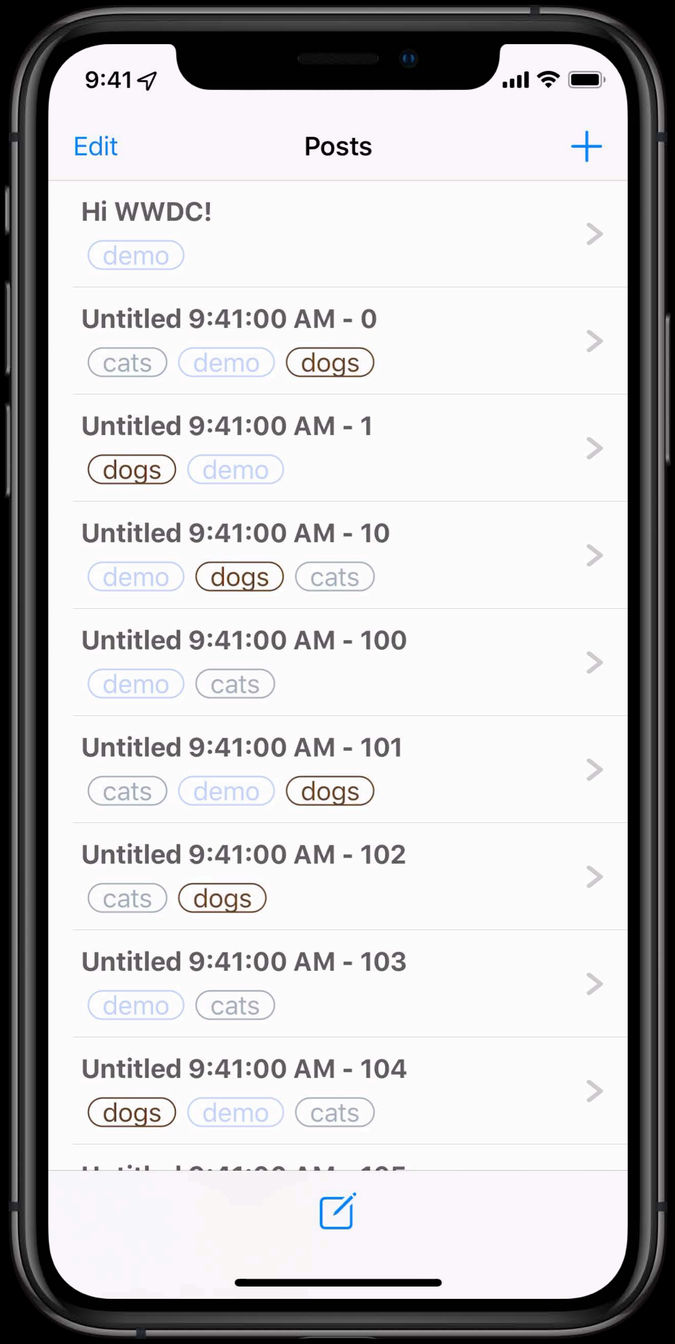

9:41
Edit
Posts
Hi WWDC!
demo
Visit the labs!
demo
Welcome to the session!
demo

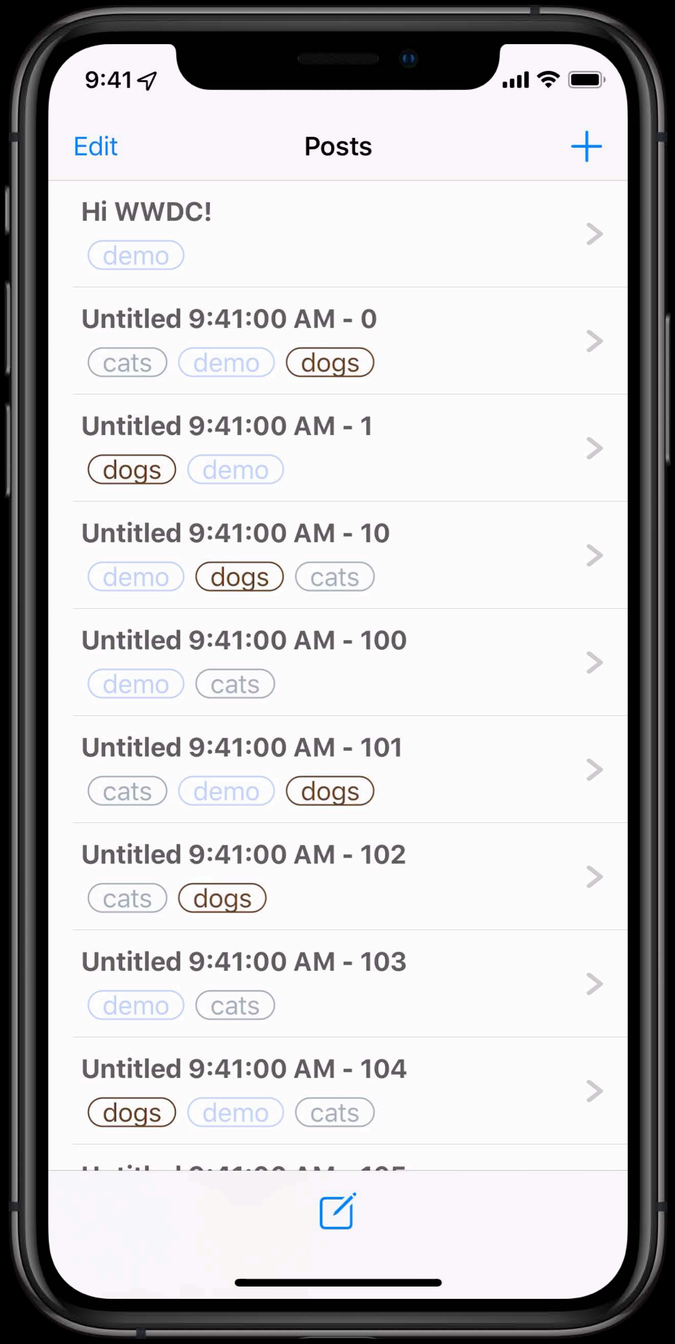

9:41
Edit
Tag
demo (3)
Dismiss


9:41
Edit
Tag
demo (3)
Dismiss


9:41
Edit
Posts
Hi WWDC!
demo
Visit the labs!
demo
Welcome to the session!
demo


9:41
Edit
Posts
Hi WWDC!
demo
Visit the labs!
demo
Welcome to the session!
demo

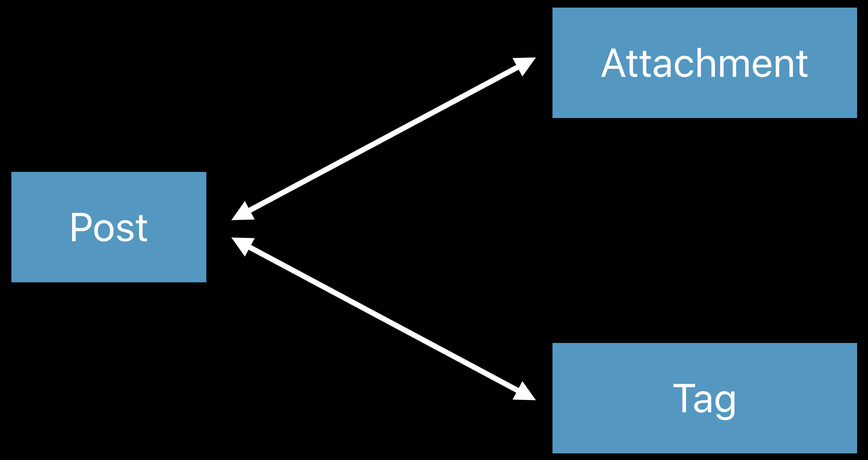

9:41
Edit
Posts
Hi WWDC!
demo
Untitled 9:41:00 AM - 0
cats
demo
dogs
Untitled 9:41:00 AM - 1
dogs
demo
Untitled 9:41:00 AM - 10
demo
dogs
cats
Untitled 9:41:00 AM - 100
demo
cats
Untitled 9:41:00 AM - 101
cats
demo
dogs
Untitled 9:41:00 AM - 102
cats
dogs
Untitled 9:41:00 AM - 103
demo
cats
Untitled 9:41:00 AM - 104
dogs
demo
cats


9:41
Edit
Posts
Hi WWDC!
demo
Untitled 9:41:00 AM - 0
cats
demo
dogs
Untitled 9:41:00 AM - 1
dogs
demo
Untitled 9:41:00 AM - 10
demo
dogs
cats
Untitled 9:41:00 AM - 100
demo
cats
Untitled 9:41:00 AM - 101
cats
demo
dogs
Untitled 9:41:00 AM - 102
cats
dogs
Untitled 9:41:00 AM - 103
demo
cats
Untitled 9:41:00 AM - 104
dogs
demo
cats

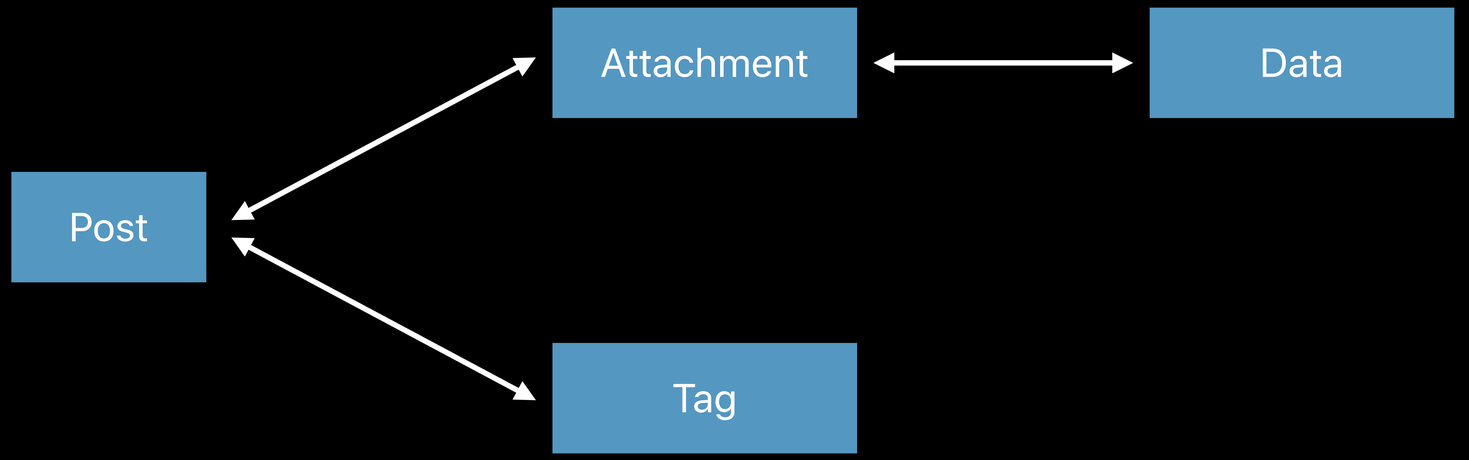
Modeling Data

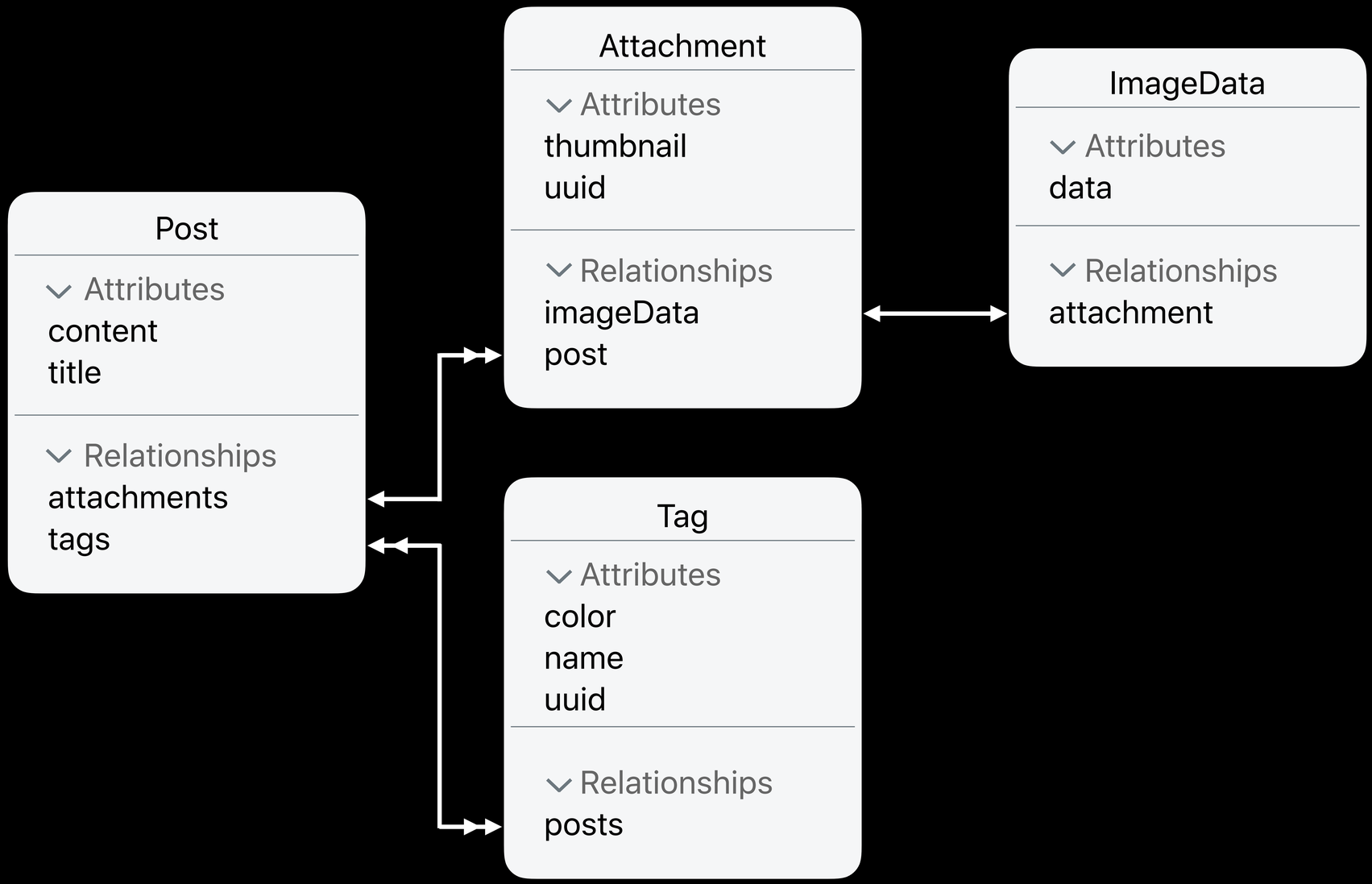
Modeling Data

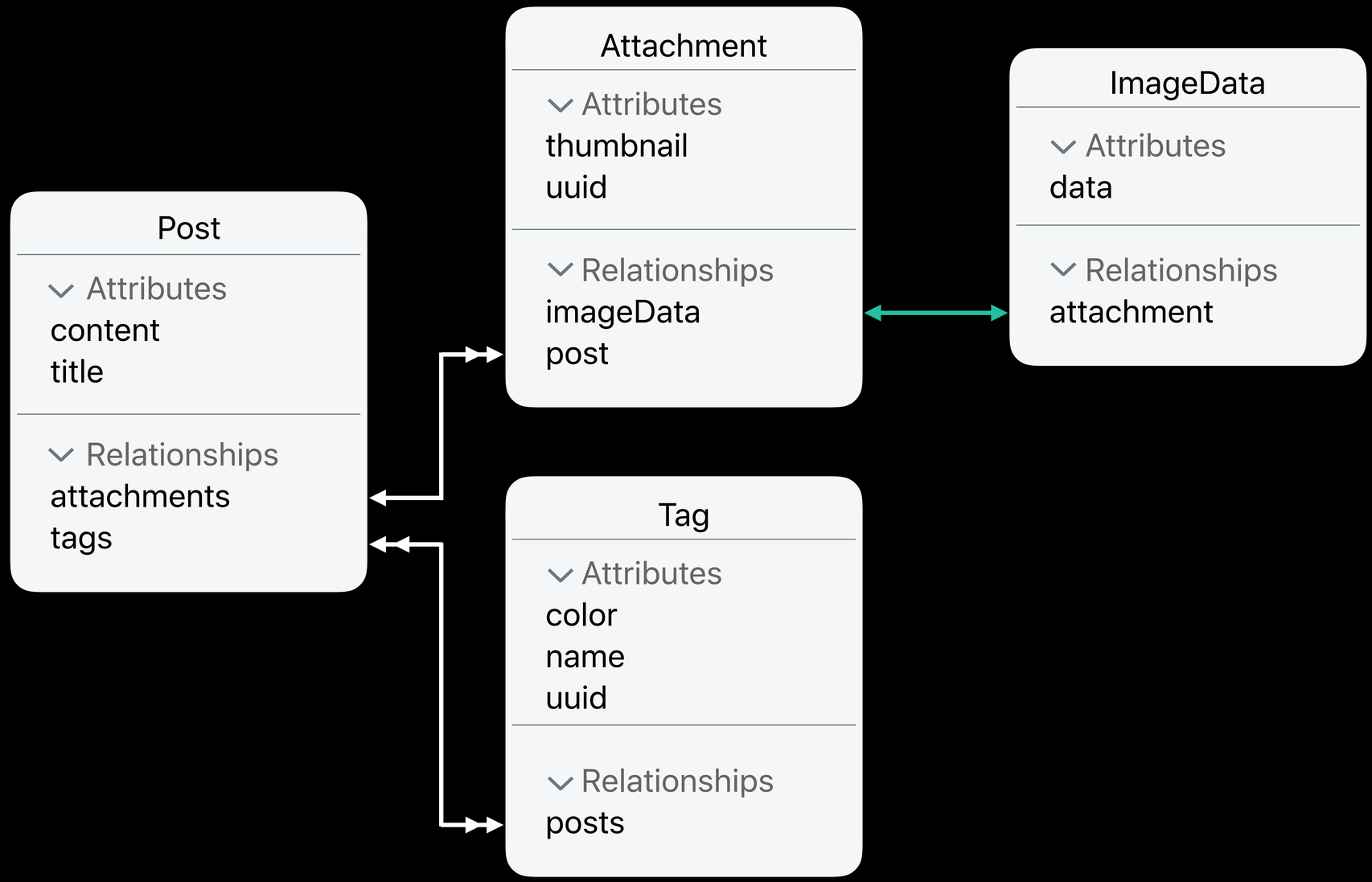
Modeling Data

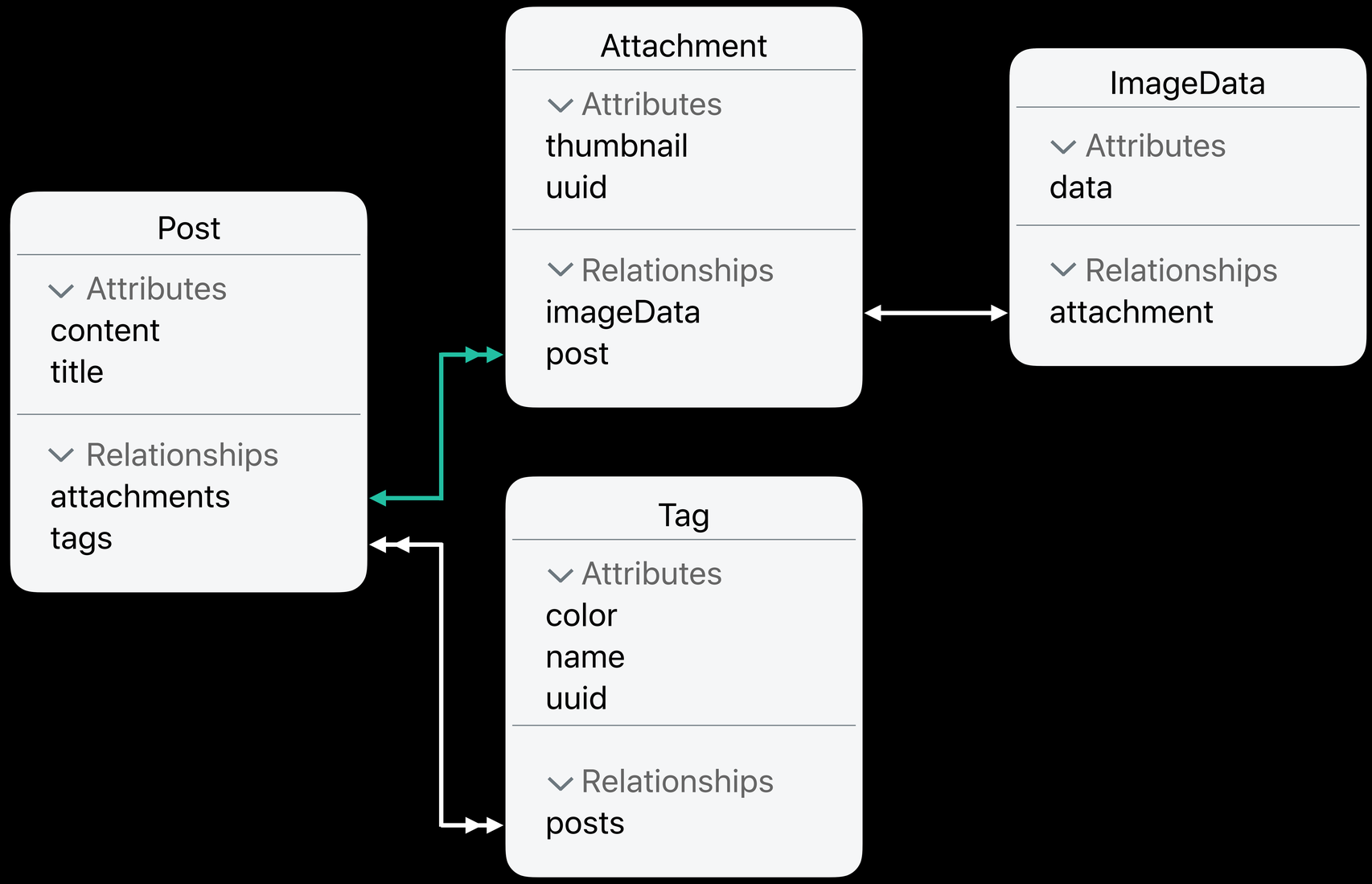


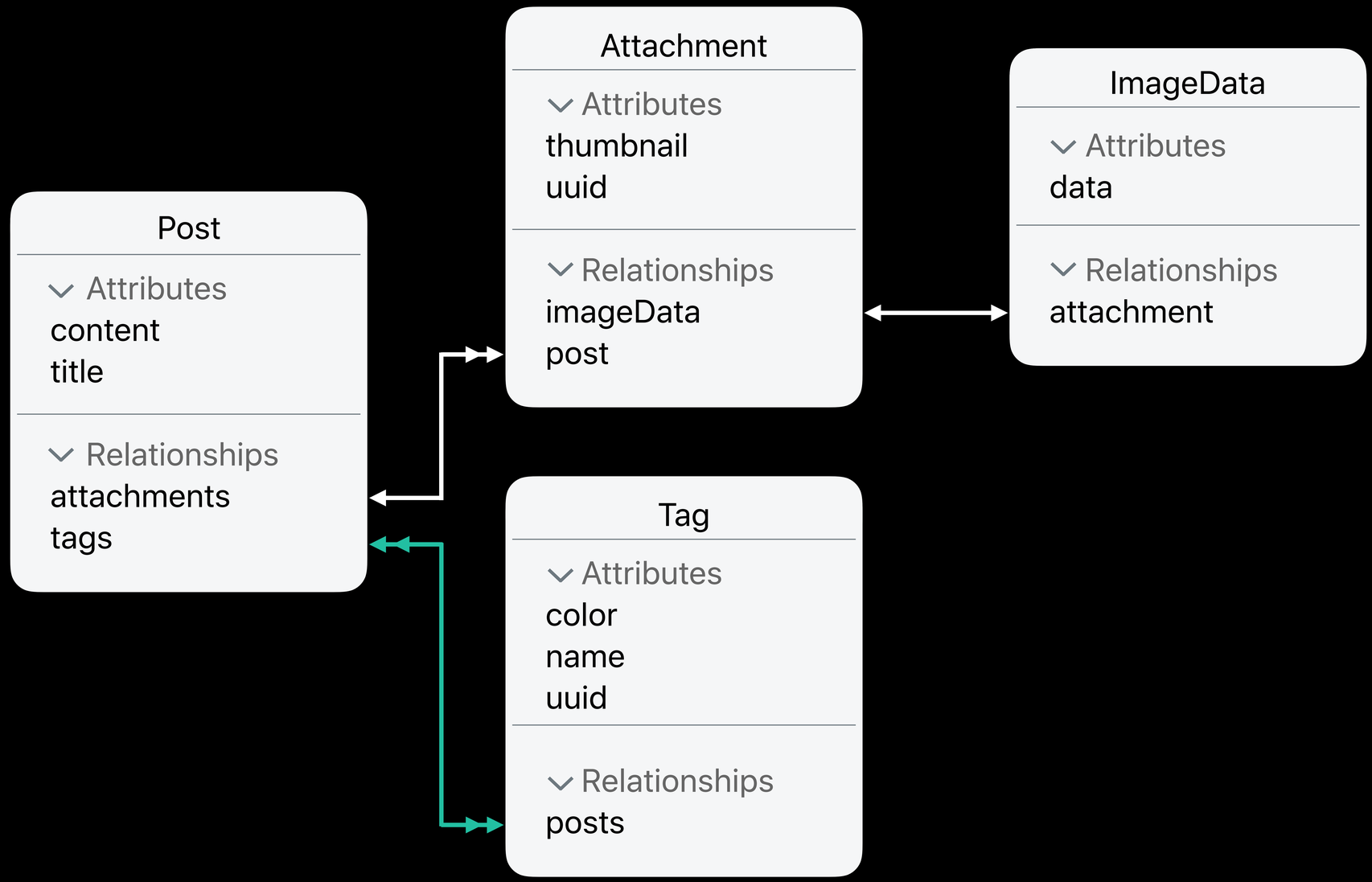
Modeling Data




Post
Attributes
content
title
Relationships
attachments
tags
Attachment
Attributes
thumbnail
uuid
Relationships
imageData
post
ImageData
Attributes
data
Relationships
attachment
Tag
Attributes
color
name
uuid
Relationships
posts


Post
Attributes
content
title
Relationships
attachments
tags
Attachment
Attributes
thumbnail
uuid
Relationships
imageData
post
ImageData
Attributes
data
Relationships
attachment
Tag
Attributes
color
name
uuid
Relationships
posts


Post
Attributes
content
title
Relationships
attachments
tags
Attachment
Attributes
thumbnail
uuid
Relationships
imageData
post
ImageData
Attributes
data
Relationships
attachment
Tag
Attributes
color
name
uuid
Relationships
posts


Post
Attributes
content
title
Relationships
attachments
tags
Attachment
Attributes
thumbnail
uuid
Relationships
imageData
post
ImageData
Attributes
data
Relationships
attachment
Tag
Attributes
color
name
uuid
Relationships
posts

The Core Data Stack

The Core Data Stack

Model

`NSManagedObjectModel`

The Core Data Stack

Model

`NSManagedObjectModel`

Store coordinator

`NSPersistentStoreCoordinator`

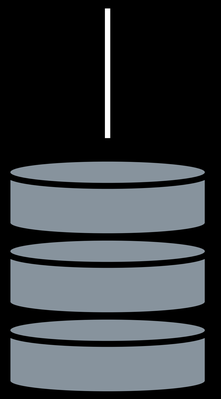
The Core Data Stack

Model

`NSManagedObjectModel`

Store coordinator

`NSPersistentStoreCoordinator`



The Core Data Stack

Model

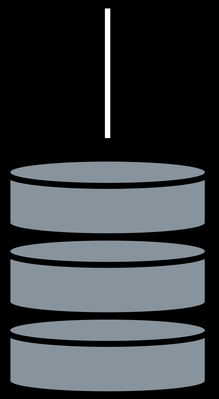
`NSManagedObjectModel`

Context

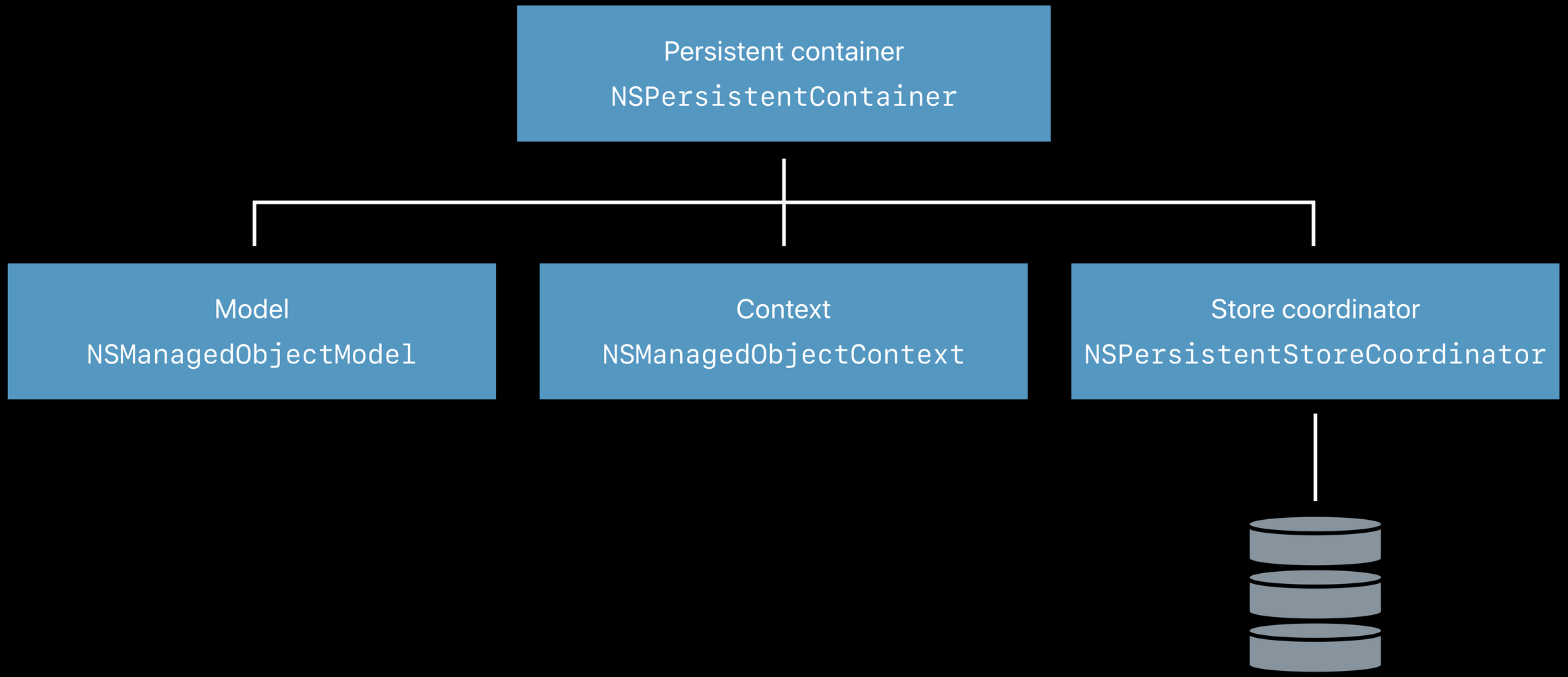
`NSManagedObjectContext`

Store coordinator

`NSPersistentStoreCoordinator`



The Core Data Stack



Setting Up the Stack

By name

```
let container = NSPersistentCloudKitContainer(name: “CoreDataCloudKitDemo")
```

Setting Up the Stack

By name

```
let container = NSPersistentCloudKitContainer(name: “CoreDataCloudKitDemo")
```

With a model

```
let container = NSPersistentCloudKitContainer(
    name: "CoreDataCloudKitDemo",
    managedObjectModel:model)
```

Setting Up the Stack

By name

```
let container = NSPersistentCloudKitContainer(name: “CoreDataCloudKitDemo")
container.loadPersistentStores { _, error in /* ... */ }
```

With a model

```
let container = NSPersistentCloudKitContainer(
    name: "CoreDataCloudKitDemo",
    managedObjectModel:model)
container.loadPersistentStores { _, error in /* ... */ }
```

Configuring Managed Object Contexts

Configuring Managed Object Contexts

Query generations provide stability

```
try container.viewContext.setQueryGenerationFrom(.current)
```

Configuring Managed Object Contexts

Query generations provide stability

```
try container.viewContext.setQueryGenerationFrom(.current)
```

Automatic merging provides freshness

```
context.automaticallyMergesChangesFromParent = true
```

Using Managed Object Contexts

Using Managed Object Contexts

```
context.performAndWait {
    /* ... */
}

context.perform {
    /* ... */
}

container.performBackgroundTask { context in
    /* ... */
}
```

Apps Need Data!

Use init(context:) to create individual managed objects

Apps Need Data!

Use init(context:) to create individual managed objects

```
context.perform {
    let post = Post(context: context)
    post.title = "Hello, world!"
    try? context.save()
}
```

Apps need *more* data!

Batch Insertions

Insert many managed objects with a fraction of the overhead

```
let rawPostsData: Data = // Server response ...
if let postDicts = try? JSONSerialization.jsonObject(with:rawPostsData) as? [[String : Any]] {
    context.perform {
        let insertRequest = NSBatchInsertRequest(entity: Post.entity(), objects: postDicts)
        let insertResult = try? context.execute(insertRequest) as! NSBatchInsertRequest
        let success = insertResult.result as! Bool
    }
}
```

Batch Insertions

NEW

Insert many managed objects with a fraction of the overhead

```
let rawPostsData: Data = // Server response ...
if let postDicts = try? JSONSerialization.jsonObject(with:rawPostsData) as? [[String : Any]] {
    context.perform {
        let insertRequest = NSBatchInsertRequest(entity: Post.entity(), objects: postDicts)
        let insertResult = try? context.execute(insertRequest) as! NSBatchInsertRequest
        let success = insertResult.result as! Bool
    }
}
```

Batch Insertions

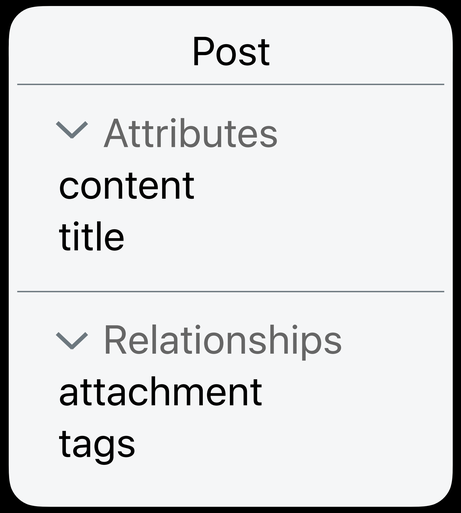
NEW

Insert many managed objects with a fraction of the overhead

```
let rawPostsData: Data = // Server response ...
if let postDicts = try? JSONSerialization.jsonObject(with:rawPostsData) as? [[String : Any]] {
    context.perform {
        let insertRequest = NSBatchInsertRequest(entity: Post.entity(), objects: postDicts)
        let insertResult = try? context.execute(insertRequest) as! NSBatchInsertRequest
        let success = insertResult.result as! Bool
    }
}
```

Batch Insertions

```
[
  [
    "content": "Lorem ipsum dolor sit amet…"
    "title"  : "Hello, world!",
  ],
  [
    "content": "This post has no title!"
  ],
  [
    "title": "Content coming soon!"
  ]
]
```



Batch Insertions

NEW

Insert many managed objects with a fraction of the overhead

```
let rawPostsData = // ...
if let postDicts = try? JSONSerialization.jsonObject(with:rawPostsData) as? [String : Any] {
    moc.perform {
        let insertRequest = NSBatchInsertRequest(entity: Post.entity(), objects: postDicts)
        let insertResult = try? moc.execute(insertRequest) as! NSBatchInsertRequest
        let success = insertResult.result as! Bool
    }
}
```

Batch Insertions

NEW

Insert many managed objects with a fraction of the overhead

```
let rawPostsData = // ...
if let postDicts = try? JSONSerialization.jsonObject(with:rawPostsData) as? [String : Any] {
    moc.perform {
        let insertRequest = NSBatchInsertRequest(entity: Post.entity(), objects: postDicts)
        let insertResult = try? moc.execute(insertRequest) as! NSBatchInsertRequest
        let success = insertResult.result as! Bool
    }
}
```

But What About…

But What About…

Unique constraints

But What About…

Unique constraints

Omitted keys

But What About…

Unique constraints

Omitted keys

Relationships

But What About…

Unique constraints

Omitted keys

Relationships

Notifications

Getting started

The needs of the Controller

Scaling your app

Testing

Fetching an Object

```
let fetchRequest : NSFetchRequest<Tag> = Tag.fetchRequest()

fetchRequest.predicate = NSPredicate(format: "name = %@", tagName)

if let tag = try? fetchRequest.execute().first {

    tagLabel.text = tag.name
    tagLabel.textColor = tag.color as? UIColor

}
```

Fetching an Object

```
let fetchRequest : NSFetchRequest<Tag> = Tag.fetchRequest()

fetchRequest.predicate = NSPredicate(format: "name = %@", tagName)

if let tag = try? fetchRequest.execute().first {

    tagLabel.text = tag.name
    tagLabel.textColor = tag.color as? UIColor

}
```

Fetching an Object

```
let fetchRequest : NSFetchRequest<Tag> = Tag.fetchRequest()

fetchRequest.predicate = NSPredicate(format: "name = %@", tagName)

if let tag = try? fetchRequest.execute().first {

    tagLabel.text = tag.name
    tagLabel.textColor = tag.color as? UIColor

}
```

Fetching an Object

```
let fetchRequest : NSFetchRequest<Tag> = Tag.fetchRequest()

fetchRequest.predicate = NSPredicate(format: "name = %@", tagName)

if let tag = try? fetchRequest.execute().first {

    tagLabel.text = tag.name
    tagLabel.textColor = tag.color as? UIColor

}
```

Fetching an Object

```
let fetchRequest : NSFetchRequest<Tag> = Tag.fetchRequest()

fetchRequest.predicate = NSPredicate(format: "name = %@", tagName)

if let tag = try? fetchRequest.execute().first {

    tagLabel.text = tag.name
    tagLabel.textColor = tag.color as? UIColor

}
```

Fetching an Object

```
let fetchRequest : NSFetchRequest<Tag> = Tag.fetchRequest()

fetchRequest.predicate = NSPredicate(format: "name = %@", tagName)

if let tag = try? fetchRequest.execute().first {

    tagLabel.text = tag.name
    tagLabel.textColor = tag.color as? UIColor

}
```

Fetching an Object

```
let fetchRequest : NSFetchRequest<Tag> = Tag.fetchRequest()

fetchRequest.predicate = NSPredicate(format: "name = %@", tagName)

if let tag = try? fetchRequest.execute().first {

    tagLabel.text = tag.name
    tagLabel.textColor = tag.color as? UIColor

}
```

Fetching an Object

```
let fetchRequest : NSFetchRequest<Tag> = Tag.fetchRequest()

fetchRequest.predicate = NSPredicate(format: "name = %@", tagName)

if let tag = try? fetchRequest.execute().first {

    tagLabel.text = tag.name
    tagLabel.textColor = tag.color as? UIColor

}
```

Wiring Views

```
let fetchRequest : NSFetchRequest<Tag> = Tag.fetchRequest()

fetchRequest.predicate = NSPredicate(format: "name = %@", tagName)

if let tag = try? fetchRequest.execute().first {

    nameSubscription = tag.publisher(for: \.name)
                          .assign(to: \.text, on: tagLabel)

    colorSubscription = tag.publisher(for: \.color)
                           .map({ $0 as? UIColor })
                           .assign(to: \.textColor, on: tagLabel)

}
```

Wiring Views

```
let fetchRequest : NSFetchRequest<Tag> = Tag.fetchRequest()

fetchRequest.predicate = NSPredicate(format: "name = %@", tagName)

if let tag = try? fetchRequest.execute().first {

    nameSubscription = tag.publisher(for: \.name)
                          .assign(to: \.text, on: tagLabel)

    colorSubscription = tag.publisher(for: \.color)
                           .map({ $0 as? UIColor })
                           .assign(to: \.textColor, on: tagLabel)

}
```

Wiring Detail Views

```
if let tag = tag {

    nameSubscription = tag.publisher(for: \.name)
                          .assign(to: \.text, on: tagLabel)

    colorSubscription = tag.publisher(for: \.color)
                           .map({ $0 as? UIColor })
                           .assign(to: \.textColor, on: tagLabel)

}
```

Fetching Many Objects

Sort results

```
fetchRequest.sortDescriptors = [NSSortDescriptor(key: "name", ascending: true)]
```

Fetching Many Objects

Sort results

```
fetchRequest.sortDescriptors = [NSSortDescriptor(key: "name", ascending: true)]
```

Batched fetching

```
fetchRequest.fetchBatchSize = 50
```

Live Queries

Live Queries

```
let fetchRequest: NSFetchRequest<Post> = Post.fetchRequest()

fetchRequest.sortDescriptors = [NSSortDescriptor(key: "title", ascending: true)]
fetchRequest.fetchBatchSize = 50
```

Live Queries

```
let fetchRequest: NSFetchRequest<Post> = Post.fetchRequest()

fetchRequest.sortDescriptors = [NSSortDescriptor(key: "title", ascending: true)]
fetchRequest.fetchBatchSize = 50

let controller = NSFetchedResultsController(fetchRequest: fetchRequest,
                                            managedObjectContext: moc,
                                            sectionNameKeyPath: nil, cacheName: nil)

controller.delegate = self

try! controller.performFetch()
```

Fetched Results Controller Delegate Methods

```
controllerWillChangeContent(:)


controller(:didChange:atSectionIndex:for:)


controller(:didChange:at:for:newIndexPath:)


controllerDidChangeContent(:)
```

Fetched Results Controller Delegate Methods

```
controllerWillChangeContent(:)

controller(:didChange:atSectionIndex:for:)

controller(:didChange:at:for:newIndexPath:)

controllerDidChangeContent(:)
```

Fetched Results Controller Delegate Methods

```
controllerWillChangeContent(:)

controller(:didChange:atSectionIndex:for:)

controller(:didChange:at:for:newIndexPath:)

controllerDidChangeContent(:)
```

Fetched Results Controller Delegate Methods

```
controllerWillChangeContent(:)

controller(:didChange:atSectionIndex:for:)

controller(:didChange:at:for:newIndexPath:)

controllerDidChangeContent(:)
```

Fetched Results Controller Delegate Methods

```
controllerWillChangeContent(:)

controller(:didChange:atSectionIndex:for:)

controller(:didChange:at:for:newIndexPath:)

controllerDidChangeContent(:)
```

Fetched Results Controller Delegate Methods

```
controllerWillChangeContent(:)

controller(:didChange:atSectionIndex:for:)

controller(:didChange:at:for:newIndexPath:)

controllerDidChangeContent(:)
```

Fetched Results Controller Delegate Methods

```
controllerWillChangeContent(:)

controller(:didChange:atSectionIndex:for:)

controller(:didChange:at:for:newIndexPath:)

controllerDidChangeContent(:)
```

Fetched Results Controller Delegate Methods

```
controllerWillChangeContent(:)

controller(:didChange:atSectionIndex:for:)

controller(:didChange:at:for:newIndexPath:)

controllerDidChangeContent(:)
```

Fetched Results Controller Delegate Methods

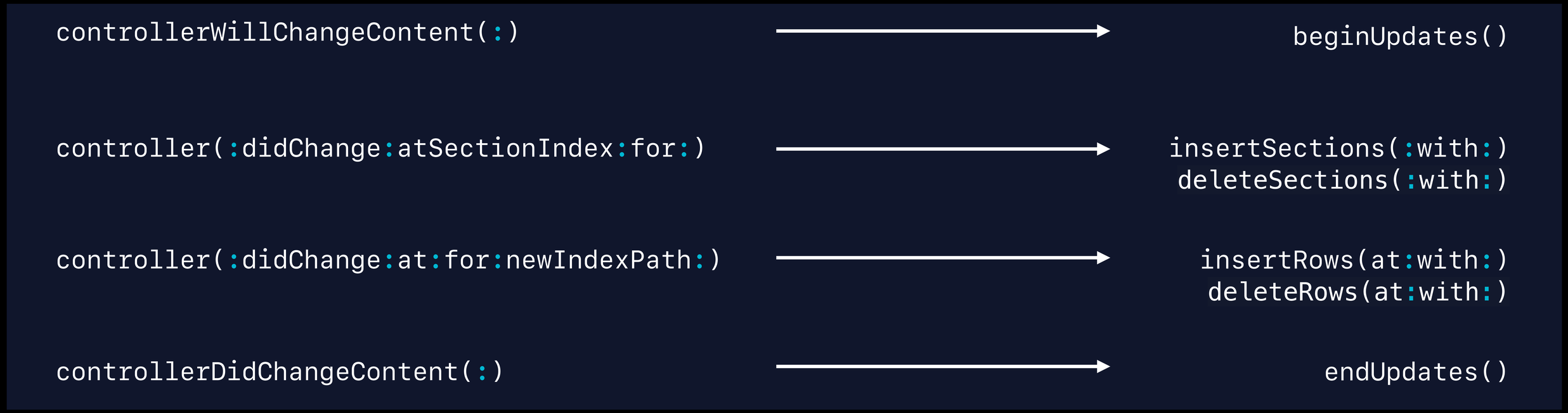
```
controllerWillChangeContent(:)


controller(:didChange:atSectionIndex:for:)


controller(:didChange:at:for:newIndexPath:)


controllerDidChangeContent(:)
```

Fetched Results Controller Delegate Methods



Fetched Results Controller Delegate Methods

`controllerWillChangeContent(:)`	`beginUpdates()`
`controller(:didChange:atSectionIndex:for:)`	`insertSections(:with:)` `deleteSections(:with:)`
`controller(:didChange:at:for:newIndexPath:)`	`insertRows(at:with:)` `deleteRows(at:with:)`
`controllerDidChangeContent(:)`	`endUpdates()`

Displaying Fetched Results Using Snapshots

New delegate method vends instances of NSDiffableDataSourceSnapshot

Snapshots encode the section and row state of a collection view

Displaying Fetched Results Using Snapshots

NEW

New delegate method vends instances of NSDiffableDataSourceSnapshot

Snapshots encode the section and row state of a collection view

Displaying Fetched Results Using Snapshots

NEW

New delegate method vends instances of NSDiffableDataSourceSnapshot

Snapshots encode the section and row state of a collection view

```
func controller(
  _ controller: NSFetchedResultsController<NSFetchRequestResult>,
  didChangeContentWith snapshot: NSDiffableDataSourceSnapshotReference<NSManagedObjectID,
NSString>
) {
    collectionViewDataSource.applySnapshot(snapshot as! NSDiffableDataSourceSnapshot)
}
```

Displaying Fetched Results Using Differences

New delegate method vends instances of CollectionDifference

Only supported when sectionNameKeyPath is nil

Great for driving individual sections of a complex view!

Displaying Fetched Results Using Differences

NEW

New delegate method vends instances of CollectionDifference

Only supported when sectionNameKeyPath is nil

Great for driving individual sections of a complex view!

Displaying Fetched Results Using Differences

NEW

New delegate method vends instances of CollectionDifference

Only supported when sectionNameKeyPath is nil

Great for driving individual sections of a complex view!

Ordered Collection Diffing (SE-0240)

Introducing Combine and Advances in Foundation WWDC 2019

```
func controller(
    _ controller: NSFetchedResultsController<NSFetchRequestResult>,
    didChangeContentWith diff: CollectionDifference<NSManagedObjectID>
) {
    collectionView.performBatchUpdates({
        for change in diff {
            switch change {
            case .insert(offset: let newRow, element: _, associatedWith: let assoc):
                if let oldRow = assoc {
                    collectionView.moveItem(
                        at: IndexPath(row: oldRow, section: frcSection),
                        to: IndexPath(row: newRow, section: frcSection))
                } else {
                    collectionView.insertItems(
                        at: [IndexPath(row: newRow, section: frcSection)])
                }
            case .remove(offset: let oldRow, element: _, associatedWith: let assoc):
                if assoc == nil {
                    collectionView.deleteItems(
                        at: [IndexPath(row: oldRow, section: frcSection)])
                }

            }
        }
    }, completion: nil)
}
```

```
func controller(
    _ controller: NSFetchedResultsController<NSFetchRequestResult>,
    didChangeContentWith diff: CollectionDifference<NSManagedObjectID>
) {
    collectionView.performBatchUpdates({
        for change in diff {
            switch change {
            case .insert(offset: let newRow, element: _, associatedWith: let assoc):
                if let oldRow = assoc {
                    collectionView.moveItem(
                        at: IndexPath(row: oldRow, section: frcSection),
                        to: IndexPath(row: newRow, section: frcSection))
                } else {
                    collectionView.insertItems(
                        at: [IndexPath(row: newRow, section: frcSection)])
                }
            case .remove(offset: let oldRow, element: _, associatedWith: let assoc):
                if assoc == nil {
                    collectionView.deleteItems(
                        at: [IndexPath(row: oldRow, section: frcSection)])
                }

            }
        }
    }, completion: nil)
}
```

```
func controller(
    _ controller: NSFetchedResultsController<NSFetchRequestResult>,
    didChangeContentWith diff: CollectionDifference<NSManagedObjectID>
) {
    collectionView.performBatchUpdates({
        for change in diff {
            switch change {
            case .insert(offset: let newRow, element: _, associatedWith: let assoc):
                if let oldRow = assoc {
                    collectionView.moveItem(
                        at: IndexPath(row: oldRow, section: frcSection),
                        to: IndexPath(row: newRow, section: frcSection))
                } else {
                    collectionView.insertItems(
                        at: [IndexPath(row: newRow, section: frcSection)])
                }
            case .remove(offset: let oldRow, element: _, associatedWith: let assoc):
                if assoc == nil {
                    collectionView.deleteItems(
                        at: [IndexPath(row: oldRow, section: frcSection)])
                }

            }
        }
    }, completion: nil)
}
```

```
func controller(
    _ controller: NSFetchedResultsController<NSFetchRequestResult>,
    didChangeContentWith diff: CollectionDifference<NSManagedObjectID>
) {
    collectionView.performBatchUpdates({
        for change in diff {
            switch change {
            case .insert(offset: let newRow, element: _, associatedWith: let assoc):
                if let oldRow = assoc {
                    collectionView.moveItem(
                        at: IndexPath(row: oldRow, section: frcSection),
                        to: IndexPath(row: newRow, section: frcSection))
                } else {
                    collectionView.insertItems(
                        at: [IndexPath(row: newRow, section: frcSection)])
                }
            case .remove(offset: let oldRow, element: _, associatedWith: let assoc):
                if assoc == nil {
                    collectionView.deleteItems(
                        at: [IndexPath(row: oldRow, section: frcSection)])
                }

            }
        }
    }, completion: nil)
}
```

```
func controller(
    _ controller: NSFetchedResultsController<NSFetchRequestResult>,
    didChangeContentWith diff: CollectionDifference<NSManagedObjectID>
) {
    collectionView.performBatchUpdates({
        for change in diff {
            switch change {
            case .insert(offset: let newRow, element: _, associatedWith: let assoc):
                if let oldRow = assoc {
                    collectionView.moveItem(
                        at: IndexPath(row: oldRow, section: frcSection),
                        to: IndexPath(row: newRow, section: frcSection))
                } else {
                    collectionView.insertItems(
                        at: [IndexPath(row: newRow, section: frcSection)])
                }
            case .remove(offset: let oldRow, element: _, associatedWith: let assoc):
                if assoc == nil {
                    collectionView.deleteItems(
                        at: [IndexPath(row: oldRow, section: frcSection)])
                }

            }
        }
    }, completion: nil)
}
```

```
func controller(
    _ controller: NSFetchedResultsController<NSFetchRequestResult>,
    didChangeContentWith diff: CollectionDifference<NSManagedObjectID>
) {
    collectionView.performBatchUpdates({
        for change in diff {
            switch change {
            case .insert(offset: let newRow, element: _, associatedWith: let assoc):
                if let oldRow = assoc {
                    collectionView.moveItem(
                        at: IndexPath(row: oldRow, section: frcSection),
                        to: IndexPath(row: newRow, section: frcSection))
                } else {
                    collectionView.insertItems(
                        at: [IndexPath(row: newRow, section: frcSection)])
                }
            case .remove(offset: let oldRow, element: _, associatedWith: let assoc):
                if assoc == nil {
                    collectionView.deleteItems(
                        at: [IndexPath(row: oldRow, section: frcSection)])
                }

            }
        }
    }, completion: nil)
}
```

```
func controller(
    _ controller: NSFetchedResultsController<NSFetchRequestResult>,
    didChangeContentWith diff: CollectionDifference<NSManagedObjectID>
) {
    collectionView.performBatchUpdates({
        for change in diff {
            switch change {
            case .insert(offset: let newRow, element: _, associatedWith: let assoc):
                if let oldRow = assoc {
                    collectionView.moveItem(
                        at: IndexPath(row: oldRow, section: frcSection),
                        to: IndexPath(row: newRow, section: frcSection))
                } else {
                    collectionView.insertItems(
                        at: [IndexPath(row: newRow, section: frcSection)])
                }
            case .remove(offset: let oldRow, element: _, associatedWith: let assoc):
                if assoc == nil {
                    collectionView.deleteItems(
                        at: [IndexPath(row: oldRow, section: frcSection)])
                }

            }
        }
    }, completion: nil)
}
```

```
func controller(
    _ controller: NSFetchedResultsController<NSFetchRequestResult>,
    didChangeContentWith diff: CollectionDifference<NSManagedObjectID>
) {
    collectionView.performBatchUpdates({
        for change in diff {
            switch change {
            case .insert(offset: let newRow, element: _, associatedWith: let assoc):
                if let oldRow = assoc {
                    collectionView.moveItem(
                        at: IndexPath(row: oldRow, section: frcSection),
                        to: IndexPath(row: newRow, section: frcSection))
                } else {
                    collectionView.insertItems(
                        at: [IndexPath(row: newRow, section: frcSection)])
                }
            case .remove(offset: let oldRow, element: _, associatedWith: let assoc):
                if assoc == nil {
                    collectionView.deleteItems(
                        at: [IndexPath(row: oldRow, section: frcSection)])
                }

            }
        }
    }, completion: nil)
}
```

```
func controller(
    _ controller: NSFetchedResultsController<NSFetchRequestResult>,
    didChangeContentWith diff: CollectionDifference<NSManagedObjectID>
) {
    collectionView.performBatchUpdates({
        for change in diff {
            switch change {
            case .insert(offset: let newRow, element: _, associatedWith: let assoc):
                if let oldRow = assoc {
                    collectionView.moveItem(
                        at: IndexPath(row: oldRow, section: frcSection),
                        to: IndexPath(row: newRow, section: frcSection))
                } else {
                    collectionView.insertItems(
                        at: [IndexPath(row: newRow, section: frcSection)])
                }
            case .remove(offset: let oldRow, element: _, associatedWith: let assoc):
                if assoc == nil {
                    collectionView.deleteItems(
                        at: [IndexPath(row: oldRow, section: frcSection)])
                }

            }
        }
    }, completion: nil)
}
```

```
func controller(
    _ controller: NSFetchedResultsController<NSFetchRequestResult>,
    didChangeContentWith diff: CollectionDifference<NSManagedObjectID>
) {
    collectionView.performBatchUpdates({
        for change in diff {
            switch change {
            case .insert(offset: let newRow, element: _, associatedWith: let assoc):
                if let oldRow = assoc {
                    collectionView.moveItem(
                        at: IndexPath(row: oldRow, section: frcSection),
                        to: IndexPath(row: newRow, section: frcSection))
                } else {
                    collectionView.insertItems(
                        at: [IndexPath(row: newRow, section: frcSection)])
                }
            case .remove(offset: let oldRow, element: _, associatedWith: let assoc):
                if assoc == nil {
                    collectionView.deleteItems(
                        at: [IndexPath(row: oldRow, section: frcSection)])
                }

            }
        }
    }, completion: nil)
}
```

Displaying Fetched Results

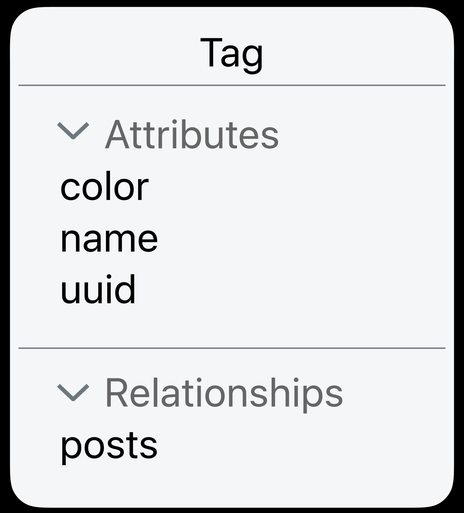
Drive declarative list views from controllerDidChangeContent(:)

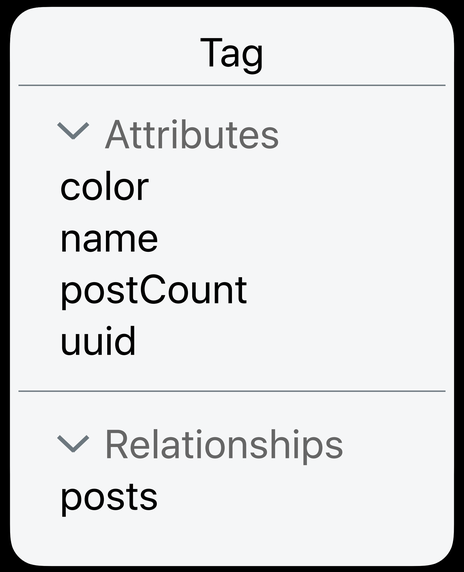
Denormalization

Improving Performance Using Denormalization

Adding redundant data to make access faster and more convenient

Redundant data requires more work


Tag
Attributes
color
name
uuid
Relationships
posts


Tag
Attributes
color
name
postCount
uuid
Relationships
posts

Derived Attributes

CoreData-managed metadata

Derived Attributes

CoreData-managed metadata

NEW

Derived Attributes

CoreData-managed metadata

NEW

Multiple supported functions

Derived Attributes

CoreData-managed metadata

NEW

Multiple supported functions

Defined in managed object model

Derived Attributes

CoreData-managed metadata

NEW

Multiple supported functions

Defined in managed object model

Available on all properties of the entity

Demo

Supported Derivations

Supported Derivations

Data duplication

Supported Derivations

Data duplication

Data transformation

Supported Derivations

Data duplication

Data transformation

To-many aggregate functions

Supported Derivations

Data duplication

Data transformation

To-many aggregate functions

Zero-parameter functions

Getting started

The needs of the Controller

Scaling your app

Testing

Fetching Persistent History

Fetching Persistent History

NEW

Fetching Persistent History

NEW

Process history generated by a specific author

Fetching Persistent History

NEW

Process history generated by a specific author

Fetch history affecting a specific type

Fetching Persistent History

NEW

Process history generated by a specific author

Fetch history affecting a specific type

Changes that happened between a two tokens

NSPersistentHistoryTransaction and NSPersistentHistoryChange

NEW

```
class func entityDescription(
    withContext context: NSManagedObjectContext
) -> NSEntityDescription?

class var entityDescription: NSEntityDescription? { get }

class var fetchRequest: NSFetchRequest? { get }
```

NSPersistentHistoryTransaction and NSPersistentHistoryChange

NEW

```
class func entityDescription(
    withContext context: NSManagedObjectContext
) -> NSEntityDescription?

class var entityDescription: NSEntityDescription? { get }

class var fetchRequest: NSFetchRequest? { get }
```

NSPersistentHistoryTransaction and NSPersistentHistoryChange

NEW

```
class func entityDescription(
    withContext context: NSManagedObjectContext
) -> NSEntityDescription?

class var entityDescription: NSEntityDescription? { get }

class var fetchRequest: NSFetchRequest? { get }
```

NSPersistentHistoryTransaction and NSPersistentHistoryChange

NEW

```
class func entityDescription(
    withContext context: NSManagedObjectContext
) -> NSEntityDescription?

class var entityDescription: NSEntityDescription? { get }

class var fetchRequest: NSFetchRequest? { get }
```

Fetching Persistent History

NEW

Fetching Persistent History

NEW

```
open class NSPersistentHistoryChangeRequest : NSPersistentStoreRequest {

    open class func fetchHistory(
        withFetch fetchRequest: NSFetchRequest<NSFetchRequestResult>
    ) -> Self

    open var fetchRequest: NSFetchRequest<NSFetchRequestResult>?

}
```

Fetching Persistent History

NEW

```
open class NSPersistentHistoryChangeRequest : NSPersistentStoreRequest {

    open class func fetchHistory(
        withFetch fetchRequest: NSFetchRequest<NSFetchRequestResult>
    ) -> Self

    open var fetchRequest: NSFetchRequest<NSFetchRequestResult>?

}
```

Fetching Persistent History

NEW

```
open class NSPersistentHistoryChangeRequest : NSPersistentStoreRequest {

    open class func fetchHistory(
        withFetch fetchRequest: NSFetchRequest<NSFetchRequestResult>
    ) -> Self

    open var fetchRequest: NSFetchRequest<NSFetchRequestResult>?

}
```

Discovering New History

Discovering New History

Poll the store?

Dispatch source?

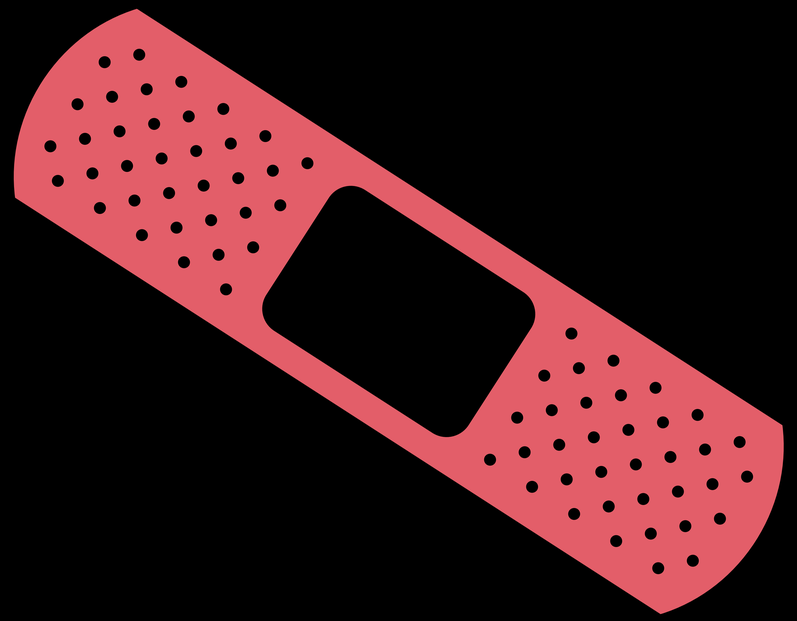
FS Events?

Discovering New History

Poll the store?

Dispatch source?

FS Events?



Remote Change Notifications

Cross-coordinator save notifications

Asynchronous

Remote Change Notifications

NEW

Cross-coordinator save notifications

Asynchronous

Remote Change Notifications

NEW

Cross-coordinator *change* notifications

Remote Change Notifications

NEW

Remote Change Notifications

NEW

```
let description: NSPersistentStoreDescription = /* ... */

description.setOption(
    true as NSNumber,
    forKey: NSPersistentStoreRemoteChangeNotificationPostOptionKey)

description.setOption(true as NSNumber, forKey: NSPersistentHistoryTrackingKey)
```

Remote Change Notifications

NEW

Remote Change Notifications

NEW

```
func storeRemoteChange(_ notification: Notification) {

    precondition(notification.name == NSNotification.Name.NSPersistentStoreRemoteChange)

    let storeURL = notification.userInfo?[NSPersistentStoreURLKey]!
    let token = notification.userInfo?[NSPersistentHistoryTokenKey]!

    print("Store at \(storeURL) was changed in transaction \(token).")

}
```

Persistent History Tokens

Persistent History Tokens

NEW

```
extension NSPersistentStoreCoordinator {

  func currentPersistentHistoryToken(
    from stores: [NSPersistentStore]?
  ) -> NSPersistentHistoryToken?

}
```

Demo

Getting started

The needs of the controller

Scaling your app

Testing

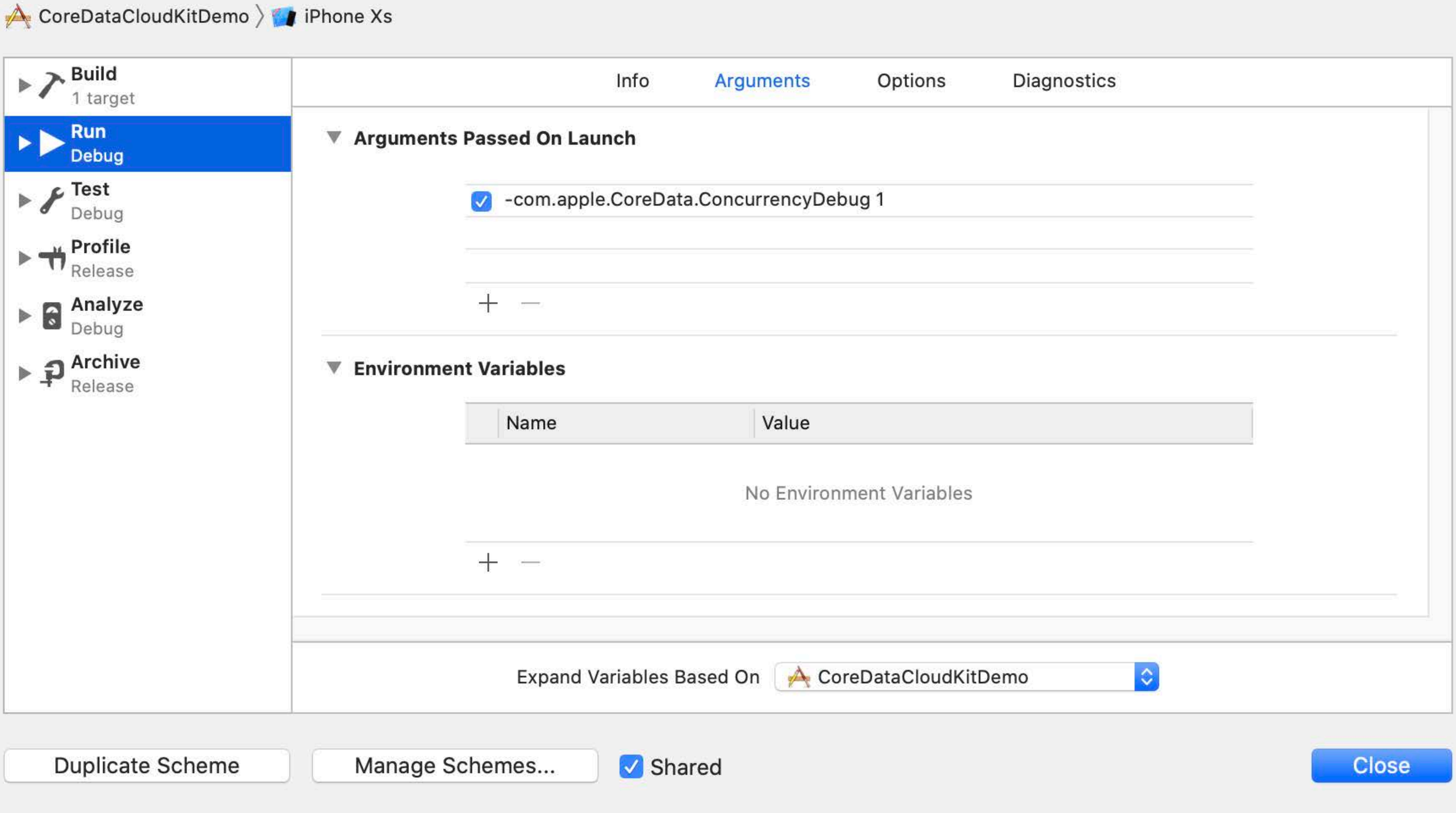
Testing Against Core Data

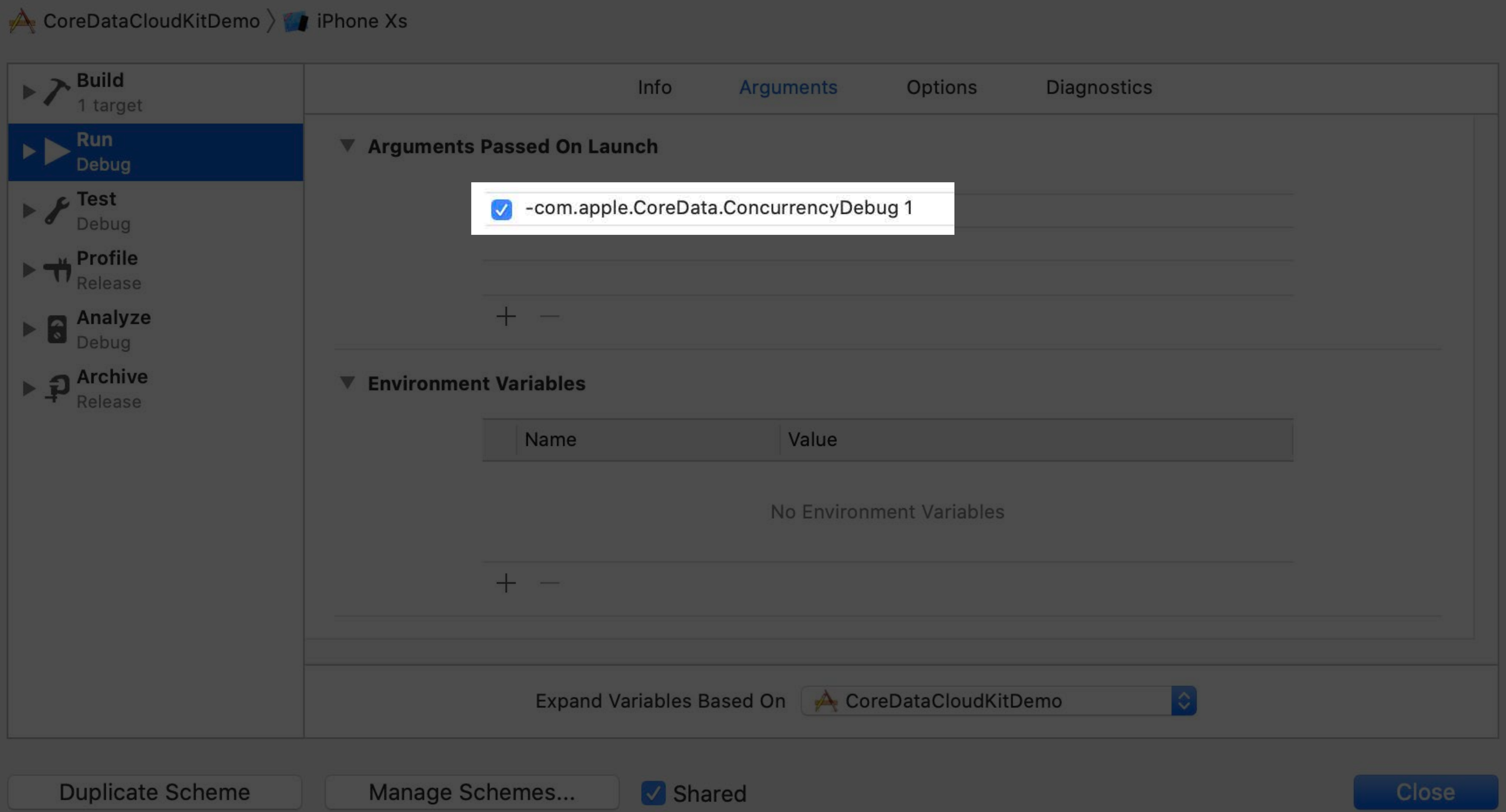
Test against actual performance goals

Testing Against Core Data

Test against actual performance goals

Run integration tests in multiple configs


CoreDataCloudKitDemo
iPhone Xs
Build
1 target
Run
Debug
Test
Debug
Profile
Release
Analyze
Debug
Archive
Release
Info
Arguments
Options
Diagnostics
Arguments Passed On Launch
-com.apple.CoreData.ConcurrencyDebug 1
Environment Variables
Name
Value
No Environment Variables
Expand Variables Based On
CoreDataCloudKitDemo
Duplicate Scheme
Manage Schemes...
Shared
Close


CoreDataCloudKitDemo
iPhone Xs
Build
1 target
Run
Debug
Test
Debug
Profile
Release
Analyze
Debug
Archive
Release
Info
Arguments
Options
Diagnostics
Arguments Passed On Launch
-com.apple.CoreData.ConcurrencyDebug 1
Environment Variables
Name
Value
No Environment Variables
Expand Variables Based On
CoreDataCloudKitDemo
Duplicate Scheme
Manage Schemes...
Shared
Close

Testing Against Core Data

Test against actual performance goals

Run integration tests in multiple configs

Testing Against Core Data

Test against actual performance goals

Run integration tests in multiple configs

Use in-memory stores where appropriate

Named In-Memory Stores

```
let container = NSPersistentCloudKitContainer(name: "CoreDataCloudKitDemo")

let description = container.persistentStoreDescriptions.first!

description.url = URL(fileURLWithPath: "/dev/null")

container.loadPersistentStores(completionHandler: { (_, error) in
  guard let error = error as NSError? else { return }
  fatalError("###\(#function): Failed to load persistent stores:\(error)")
})
```

Named In-Memory Stores

```
let container = NSPersistentCloudKitContainer(name: "CoreDataCloudKitDemo")

let description = container.persistentStoreDescriptions.first!

description.url = URL(fileURLWithPath: "/dev/null")

container.loadPersistentStores(completionHandler: { (_, error) in
  guard let error = error as NSError? else { return }
  fatalError("###\(#function): Failed to load persistent stores:\(error)")
})
```

Named In-Memory Stores

```
let container = NSPersistentCloudKitContainer(name: "CoreDataCloudKitDemo")

let description = container.persistentStoreDescriptions.first!

description.url = URL(fileURLWithPath: "/dev/null").appendingPathComponent(str)

container.loadPersistentStores(completionHandler: { (_, error) in
  guard let error = error as NSError? else { return }
  fatalError("###\(#function): Failed to load persistent stores:\(error)")
})
```

Sanitizers

Sanitizers

Address Sanitizer

Sanitizers

Address Sanitizer

Thread Sanitizer

Sanitizers

Address Sanitizer

Thread Sanitizer

Undefined Behavior Sanitizer

Getting started

The needs of the controller

Scaling your app

Testing

Feedback Assistant

More Information

developer.apple.com/wwdc19/230

CoreData Lab

Friday, 1:00


WWDC19