What’s New in Core Data on iOS

Session 303

Adam Swift
Senior Software Engineer

These are confidential sessions—please refrain from streaming, blogging, or taking pictures

Roadmap

- Concurrency
- Data protection
- Ordered relationships
- UIManagedDocument
- iCloud
- Incremental stores
- Developer tools

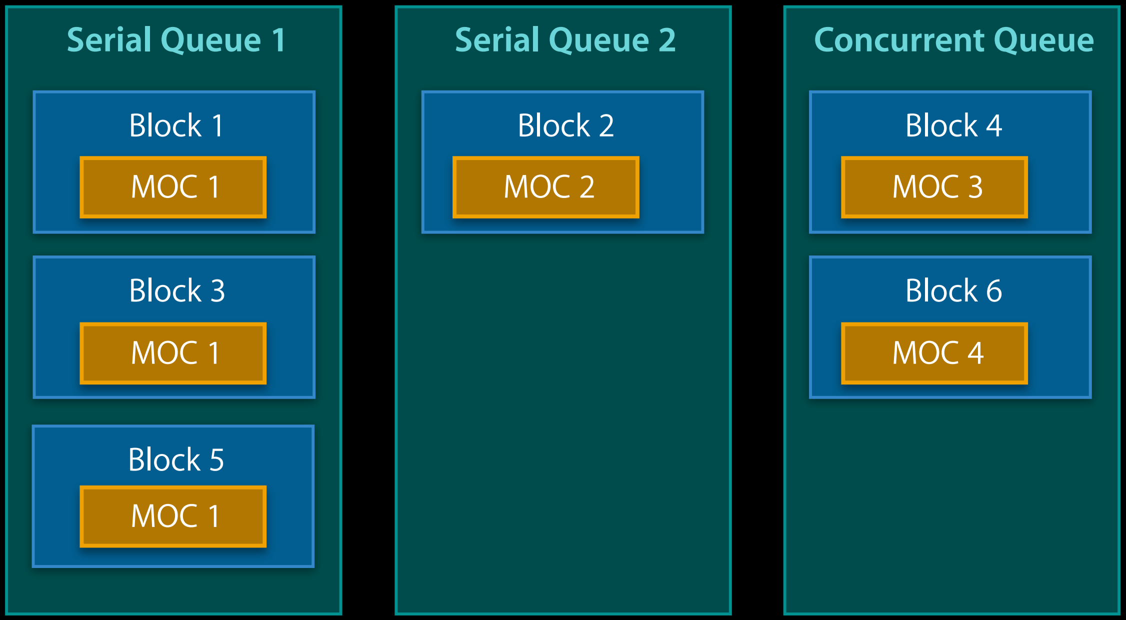
Concurrency

NSManagedObjectContext

- New concurrency types
- Block-based methods
- Nested contexts

Where We Were

Thread confinement



Thread Confinement

- Separate contexts for each thread
- Managed objects owned by their context
- ObjectIDs are safe, immutable value objects

Thread Confinement

- Easy to understand
- Safe and efficient for transactions
- But…
  - Coordination left as exercise to reader
  - Tracking which context goes with which thread
  - Passing changes between threads

What’s a Framework to Do?

Formal Concurrency Policies

- New NSManagedObjectContext initializer
  - `-initWithConcurrencyType:`

```
NSConfinementConcurrencyType
NSPrivateQueueConcurrencyType
NSMainQueueConcurrencyType
```

NSConfinementConcurrencyType

- Same behavior and restrictions as iOS 3.0–iOS 4.3
- Thread confinement
- MOCs only messaged by thread or queue that created them
- Default behavior

NSPrivateQueueConcurrencyType

- New to 10.7 and iOS 5
- Can only be called on its own private queue
- Use `-performBlock:`
- Within block use MOC APIs normally

NSMainQueueConcurrencyType

- Similar to private queue
- Queue is always the main queue
- UI and controllers on main thread can message directly
- Other threads must use `-performBlock:`
- Convenient for receiving results

Queue-Based Concurrency

- New context initializer
  - `-initWithConcurrencyType:`
  - `NSMainQueueConcurrencyType`
  - `NSPrivateQueueConcurrencyType`
- Block-based API
  - `-performBlock:`
  - `-performBlockAndWait:`

-performBlock:

- Asynchronous
- A “user event”
- Convenient autorelease pool
- No support for re-entrancy
- Illegal to throw an exception out of your block

-performBlockAndWait:

- Synchronous
- Not an event
- No autorelease pool
- Supports re-entrancy
- Illegal to throw an exception out of your block

What’s a User Event?

- Automatic as application main event loop
- Provides:
    - Change coalescing
    - Delete propagation
    - Undo
    - NSNotifications
- Time in between calls to `-processPendingChanges`

Queue Is Private

- Do not use `dispatch_get_current_queue`
- To use libdispatch or NSOperation APIs
  - Trampoline through your own queue
  - Capture references in your blocks

Interfacing with libdispatch

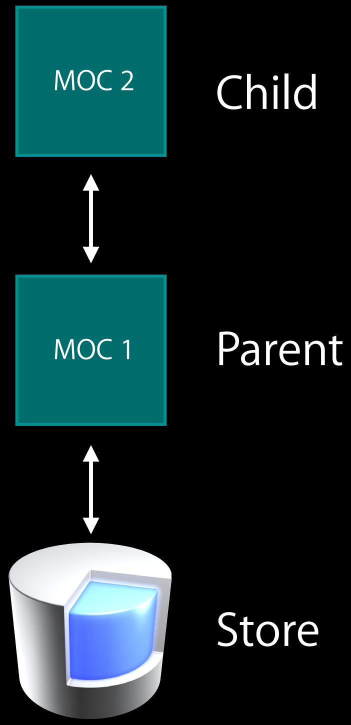
- Create a dispatch group
- Call `dispatch_group_enter`
- Worker block call `dispatch_group_leave`
- Use `dispatch_group_wait` and `dispatch_group_notify` normally

Nested NSManagedObjectContext

Nested Contexts

- Parent Context

  `setParentContext:`



Why Use Nested Contexts?

- Asynchronous saves
- Sharing unsaved changes between MOCs
    - Inheriting changes in a detail inspector
- Background fetching

Asynchronous Save

- Save child
- Asynchronously ask parent to save
- UIManagedDocument

Asynchronous Save

```
NSManagedObjectContext *child, *parent;
parent = [[NSManagedObjectContext alloc]
             initWithConcurrencyType:NSPrivateQueueConcurrencyType];
[child setParentContext:parent];
// ...
[child save:&error];
[parent performBlock:^{
    [parent save:&parentError];
}];
```

Sharing Unsaved Changes

- Shared parent context
- Push to parent
- Pull in peer child

Inheriting Changes in Detail Inspector

- Create a child context
- Save pushes changes into parent
- Fetch incorporates unsaved changes in parent
- Toss child context to cancel detail changes

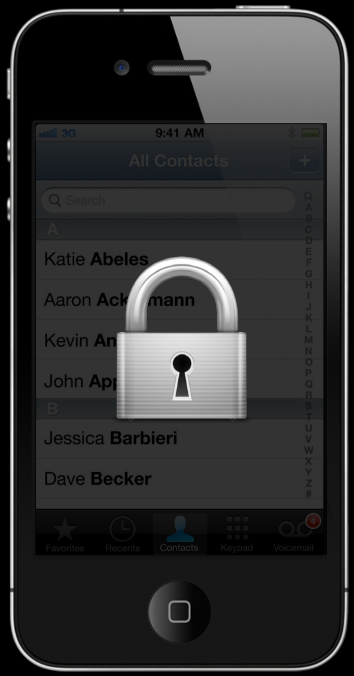
Things to Remember

- Saving only pushes changes up one level
- Fetching pulls data through all levels
- `-objectWithID:` pulls fewest levels necessary
- Parent contexts must adopt a queue type

Data Protection

Data Protection Intro

- Encrypt user data
- File-level protection
- Tied to user passcode



Data Protection Classes

- Declared in NSFileManager
- First introduced in iOS 4

```
NSFileProtectionNone
NSFileProtectionComplete
```

- New in iOS 5

```
NSFileProtectionCompleteUnlessOpen
NSFileProtectionCompleteUntilFirstUserAuthentication
```

First Boot

NSFileProtection Class	Open	Create	Read/Write
Complete Unless Open	✗	✓	✓
Complete Until First User Authentication	✗	✗	✗

Locked

NSFileProtection Class	Open	Create	Read/Write
Complete Unless Open	✗	✓	✓
Complete Until First User Authentication	✓	✓	✓

Persistent Store Protection

- Persistent store option

  `NSPersistentStoreFileProtectionKey`

- Use NSFileManager values
- Default in iOS 5

  `NSFileProtectionCompleteUntilFirstUserAuthentication`

Usage Patterns

`NSFileProtectionComplete`

- Background tasks can’t access store while locked

`NSFileProtectionCompleteUnlessOpen`

- Background tasks can’t open store while locked

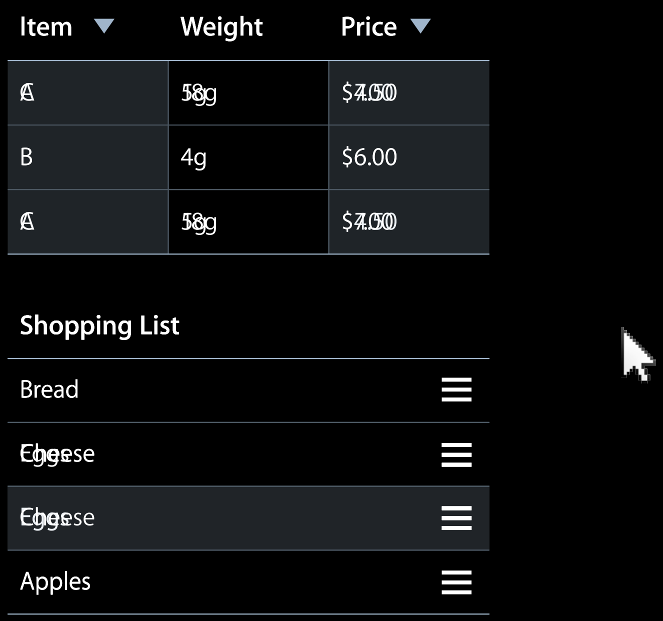
`NSFileProtectionCompleteUntilFirstUserAuthentication`

- Core Location region monitoring may trigger access before first unlock

Ordered Relationships

Sorting vs. Ordering

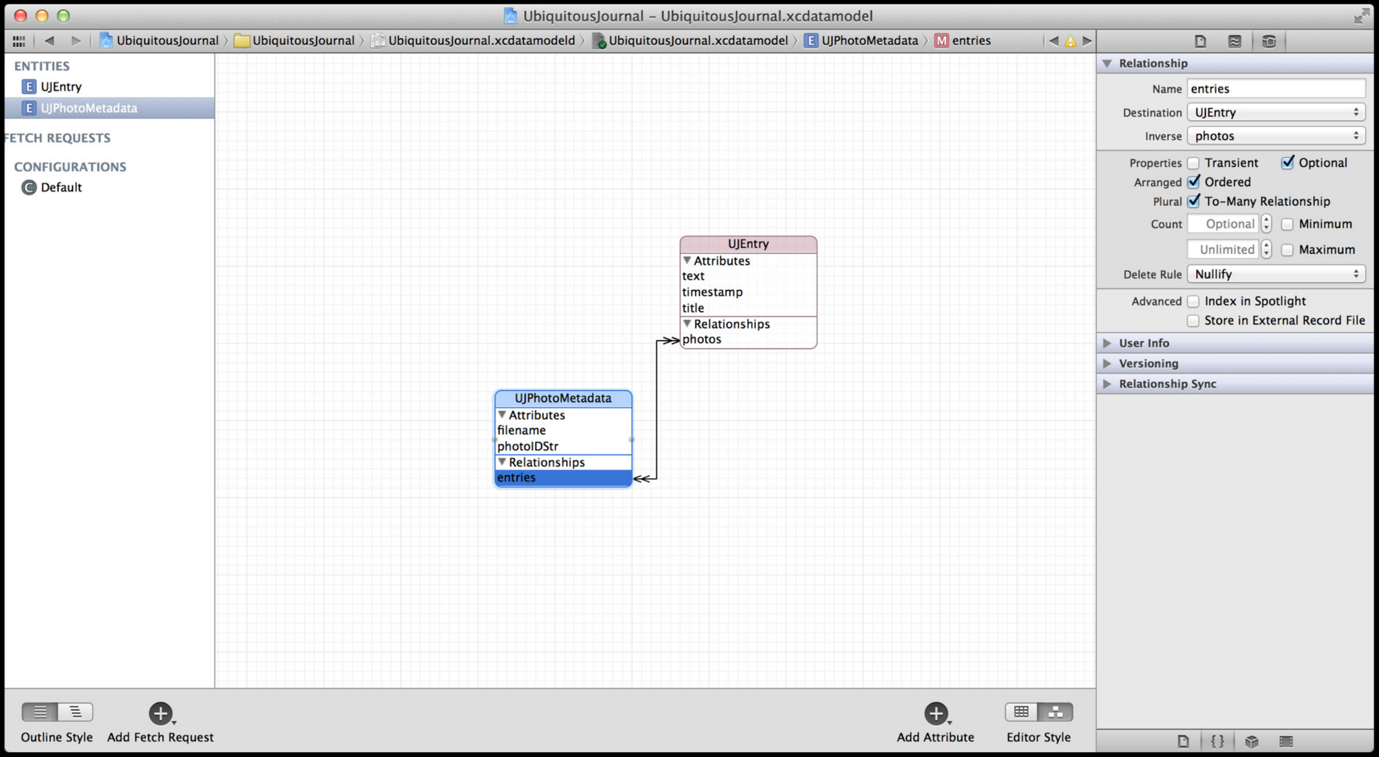
- Sorting by value
  - Derived
  - Change your view
- Arbitrary ordering
  - List
  - Flexible control
  - Not tied to any intrinsic value



Ordered Relationships

- Assign positions in to-many relationships
- NSOrderedSet
- More like an array than a set
  - Subclass of neither
- Performance impact from ordering and uniquing

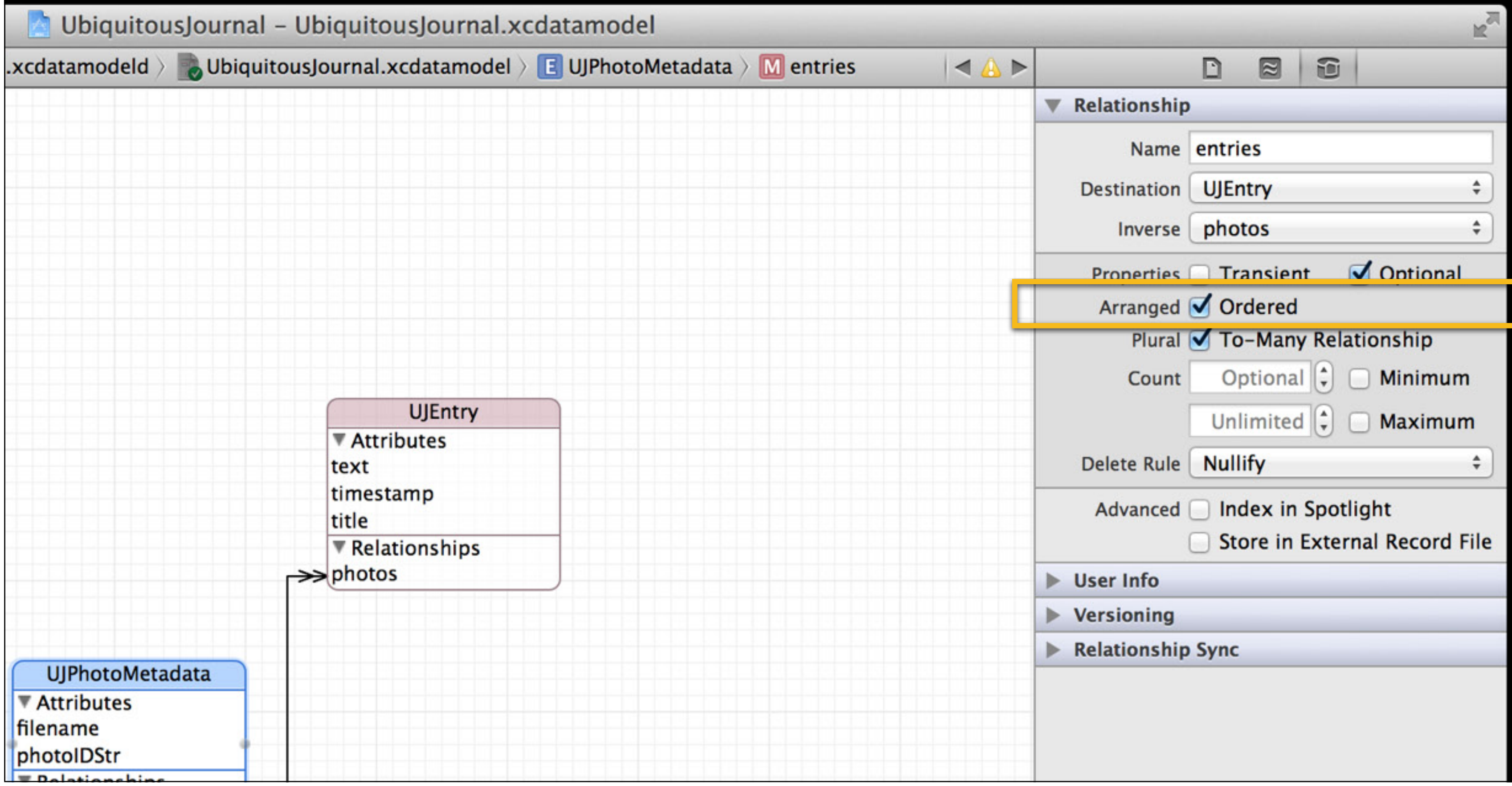
Ordered Relationships



Relationship

Name: entries
Destination: UJEntry
Inverse: photos
Properties: Transient [ ] Optional [✓]
Arranged: Ordered [✓]
Plural: To-Many Relationship [✓]
Count: Optional [ ] Minimum
Unlimited [ ] Maximum
Delete Rule: Nullify
Advanced: Index in Spotlight [ ]
Store in External Record File [ ]

Ordered Relationships


UbiquitousJournal – UbiquitousJournal.xcdatamodel

.xcdatamodeld 〉 UbiquitousJournal.xcdatamodel 〉 UJPhotoMetadata 〉 entries

Relationship

Name	entries
Destination	UJEntry
Inverse	photos
Properties	☐ Transient ✓ Optional
Arranged	✓ Ordered
Plural	✓ To-Many Relationship
Count	Optional ☐ Minimum
	Unlimited ☐ Maximum
Delete Rule	Nullify
Advanced	☐ Index in Spotlight
	☐ Store in External Record File

User Info

Versioning

Relationship Sync

Working with Ordered Relationships

- Generate accessors in Xcode 4
- Or use generic mutator

  `mutableOrderedSetValueForKey:`
- Automatic KVC accessors are not available, yet

  `insertEvents:atIndexes:, removeObjectFromEvents:atIndex:`

Observing Changes

- Key Value Observing with ordered collections

  `observeValueForKeyPath:ofObject:change:context:`

- Change kinds

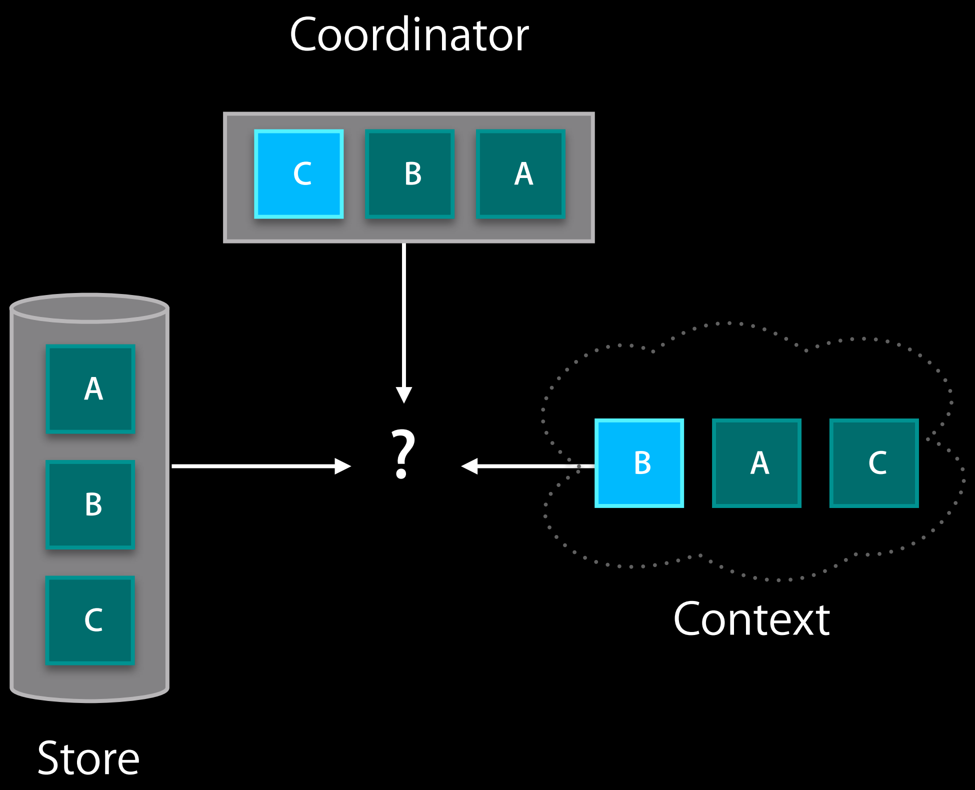
  `NSKeyValueChangeInsertion`

  `NSKeyValueChangeRemoval`

  `NSKeyValueChangeReplacement`

Merging

Three-way merging can get hairy



Merging

- We try to preserve relative ordering
- Performance is much slower than non-ordered
    - Merging existence
    - Merging position

Migration

- Non-ordered to ordered and back
- Lightweight migration gives arbitrary ordering
- Postprocess to impose ordering

Ordered Relationship Recap

- For arbitrary ordering
- Ordered collection KVC/KVO
- Performance

UIManagedDocument

Documents on iOS

- Integrated document architecture
- UIDocument gives you
    - Autosaving
    - iCloud integration
    - Asynchronous I/O

Storing Documents in iCloud Using iOS 5

Presidio
Wednesday 3:15PM

UIManagedDocument

- UIDocument-based
- Adds Core Data features
  - Scale
  - Undo
  - Graph management
  - Searching and sorting
  - Conflict resolution

Using Managed Documents

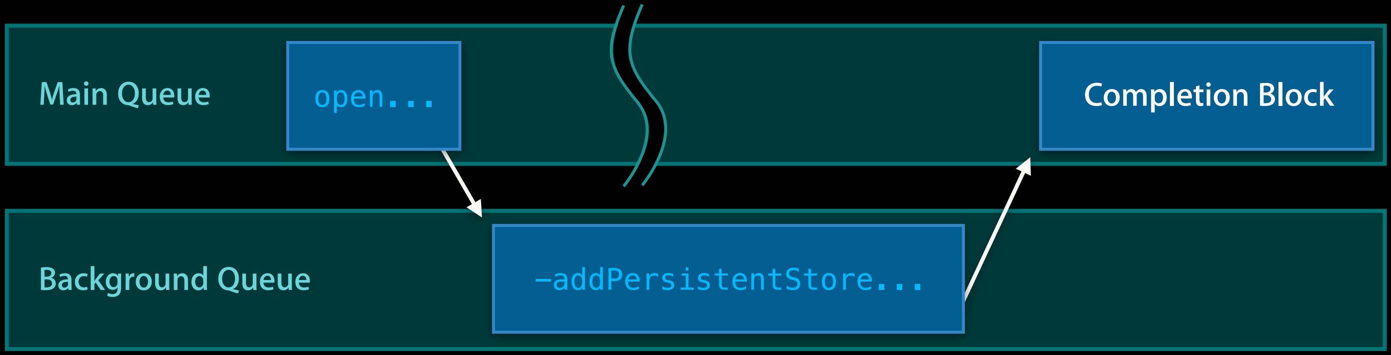
- Concrete UIDocument subclass
- Instantiate and configure
- Read data model from app bundle

Asynchronous I/O

- Don’t freeze UI
- Caller initiates open/read/save
  - Save takes snapshot synchronously
  - Provide completion handler block
- Load/write run on background queue

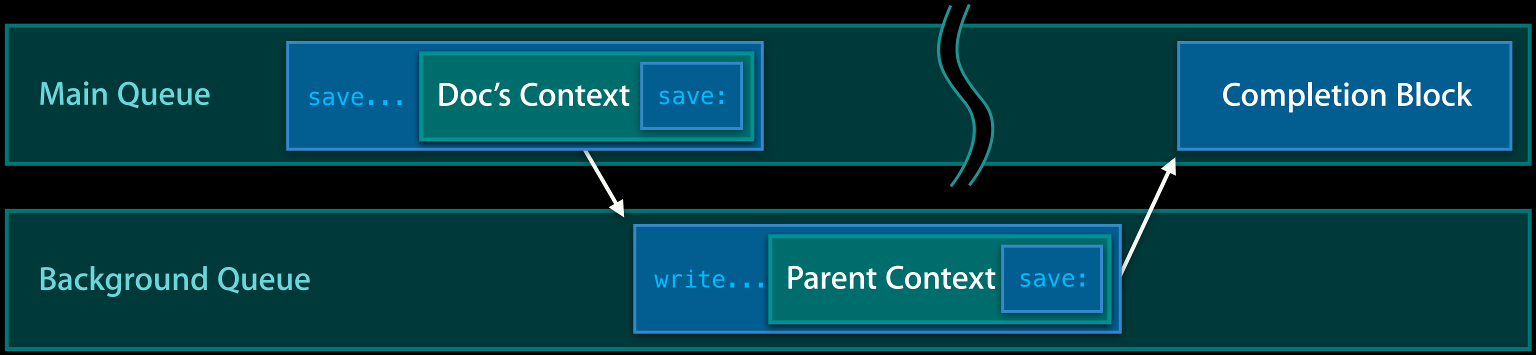
Asynchronous Load

- Simply add store at open
- Add store on background queue
  - Usually no reading
  - Migrate in background



Asynchronous Write

- Nested contexts
- Document's context on main queue
  - Takes snapshot
  - Saves to parent
- Parent context saves to disk on background queue



Unmodeled Data

- Large files should live outside the database
- Handle additional content
- Stored in document file package
- Optional API for subclasses

Additional Content API

- Read additional content

  `readAdditionalContentFromURL:error:`

- Snapshot for save

  `additionalContentForURL:error:`

- Write additional content on background queue

  `writeAdditionalContent:toURL:originalContentURL:error:`

Summary

- UIDocument architecture
- Powerful Core Data features
- Unmodeled content
- iCloud integration

iCloud

Nick Gillett
Software Engineer

Core Data, iCloud, and You

- Sync data between devices and computers
- Easy integration
- Automatic conflict resolution

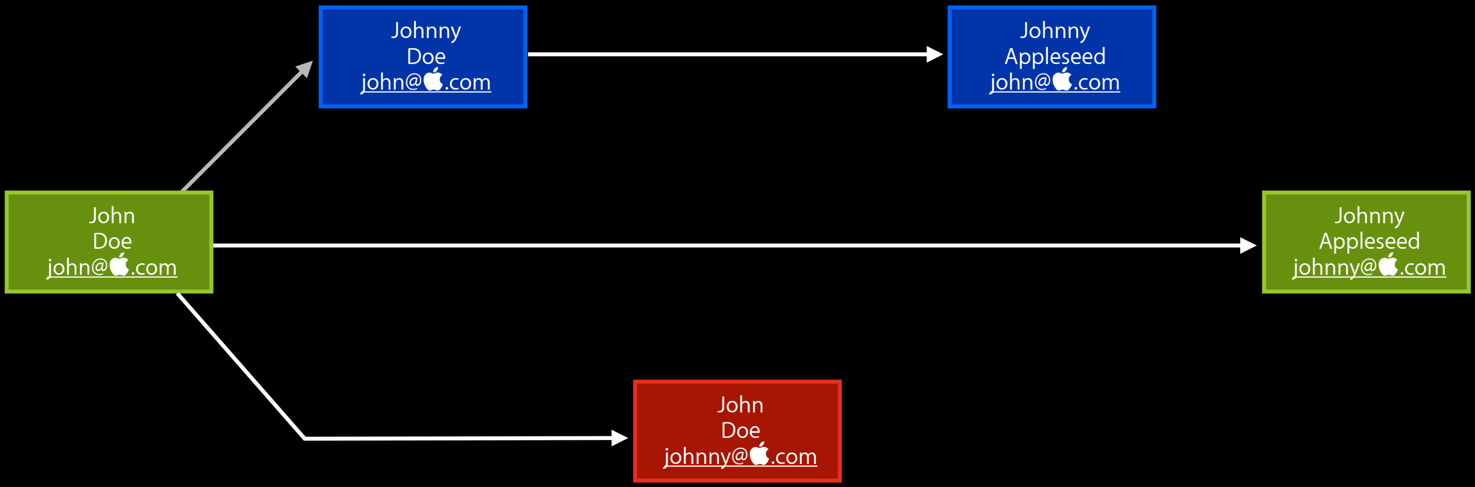
iCloud

What do you get?

- Works with existing stores
- Per record conflict resolution
- Only deltas are sync'd
- Asynchronous import
- Three-way merge

Three-Way Merge

Preserve Changes Between Systems



Less Code

Your part

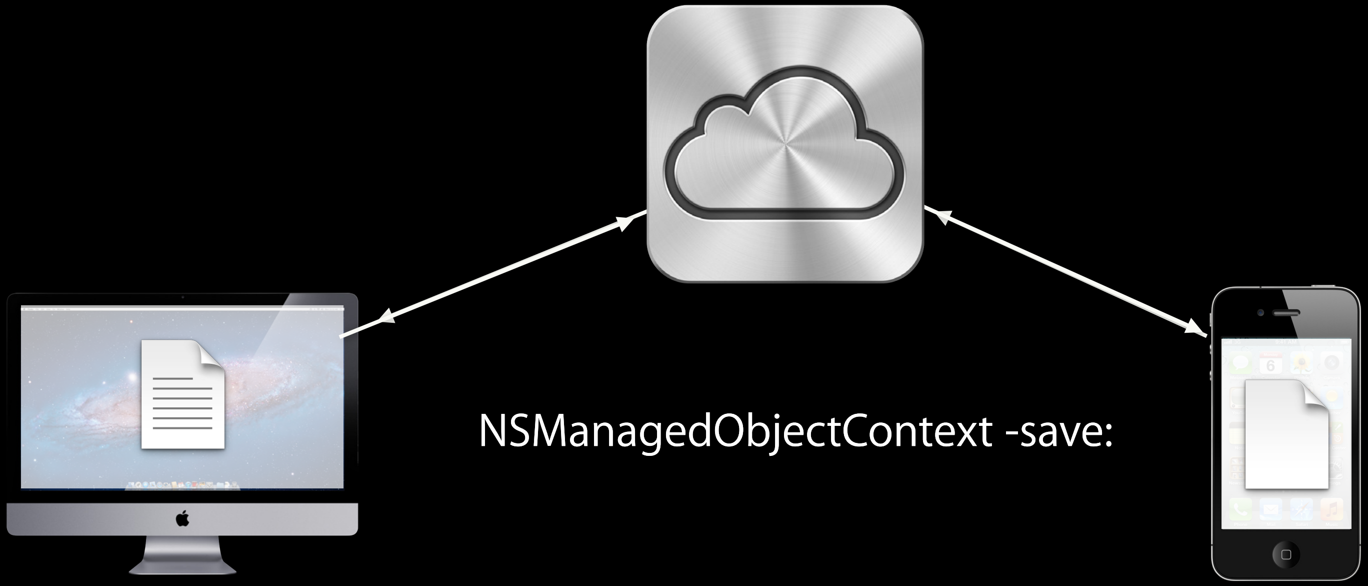
- Options when adding persistent store
- Respond to import notification

Less Code

Our part

- Handle integration
  - NSFileCoordinator
  - NSFilePresenter
  - NSMetadataQuery
- Export changes
- Import changes

How does this work?


NSManagedObjectContext -save:

New API

- Persistent Store Options
    - `NSPersistentStoreUbiquitousContentNameKey`
    - `NSPersistentStoreUbiquitousContentURLKey`
- Notification
    - `NSPersistentStoreDidImportUbiquitousContentChangesNotification`

NSPersistentStoreUbiquitousContentNameKey

datanqlite

/Users/test/data.sqlite

foodtspanic.

06302011.store

NSPersistentStoreUbiquitousContentURLKey

- Optional
- Provide your own if
  - Ubiquity Container ID != Bundle ID
  - Document syncing
- Opaque Package

NSPersistentStoreUbiquitousContentURLKey

- Defaults to main bundle identifier

```
NSString *bundleID = [[NSBundle mainBundle] bundleIdentifier];
NSURL *contentURL = [[NSFileManager defaultManager]
                       URLForUbiquityContainerID:bundleID];
```

NSPersistentStoreDidImportUbiquitousContentChangesNotification

- Object
  - NSPersistentStoreCoordinator
- User Info
  - `NSInsertedObjects`
  - `NSUpdatedObjects`
  - `NSDeletedObjects`
  - Collections of NSManagedObjectIDs

NSPersistentStoreDidImportUbiquitousContentChangesNotification

Responding to an import

- Similar to `NSManagedObjectContextDidSaveNotification`
- Refresh unchanged objects
- Merge changed objects

Document Syncing Alternatives

- Atomic stores can sync as whole files
  - SQLite should not be
- Whole store syncing
  - Don’t need ubiquitous store options
  - Last writer wins
  - Use UIDocument conflict resolution APIs

Tips and Tricks

Good ideas

`NSPersistentStoreDidImportUbiquitousContentChangesNotification`

- Use appropriate merge policy

`NSMergeByPropertyStoreTrumpMergePolicy`

`NSMergeByPropertyObjectTrumpMergePolicy`

- Anticipate bandwidth constraints
- Use .nosync

Incremental Stores

Why Do I Care?

XML-RPC Lucene REST

CouchDB In Memory

JSON SQLite SOAP

XML PostgreSQL

MongoDB Binary ThriftDB

MySQL LDAP

Incremental Store

- Talk to your data source in its own language

```
{ variety : “Brooks” ,
  reviews : [ { rating : 4 , text :  “Favorite!”} ,
              { rating : 3 , text :  “Best early choice” },
              { rating : 5 , text :  “Season is too short” } ] }
```

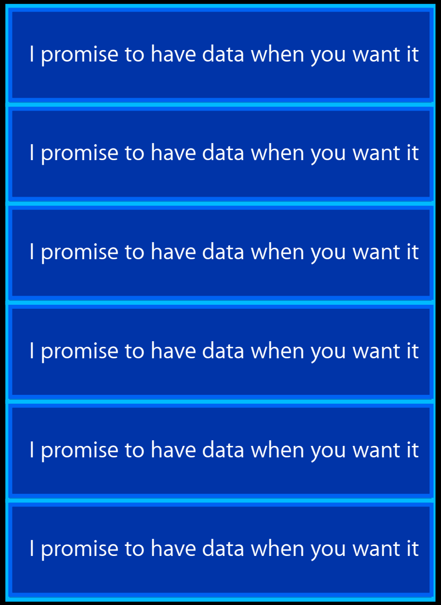
Incremental Store

- Talk to your data source in its own language
- Load only the data you need

Mark Perlson
Tom McNeil
Sumeera Razul
Lea Longo
Trisha Zarin
Greg Apodaka
Elisa Rossi
Jack Simon
Hari Seshaiah
Derrick Thornton

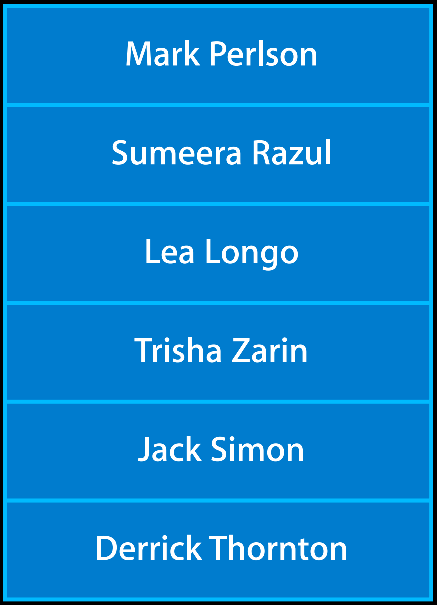
Incremental Store

- Talk to your data source in its own language
- Load only the data you need
- Supports faulting


I promise to have data when you want it
I promise to have data when you want it
I promise to have data when you want it
I promise to have data when you want it
I promise to have data when you want it
I promise to have data when you want it

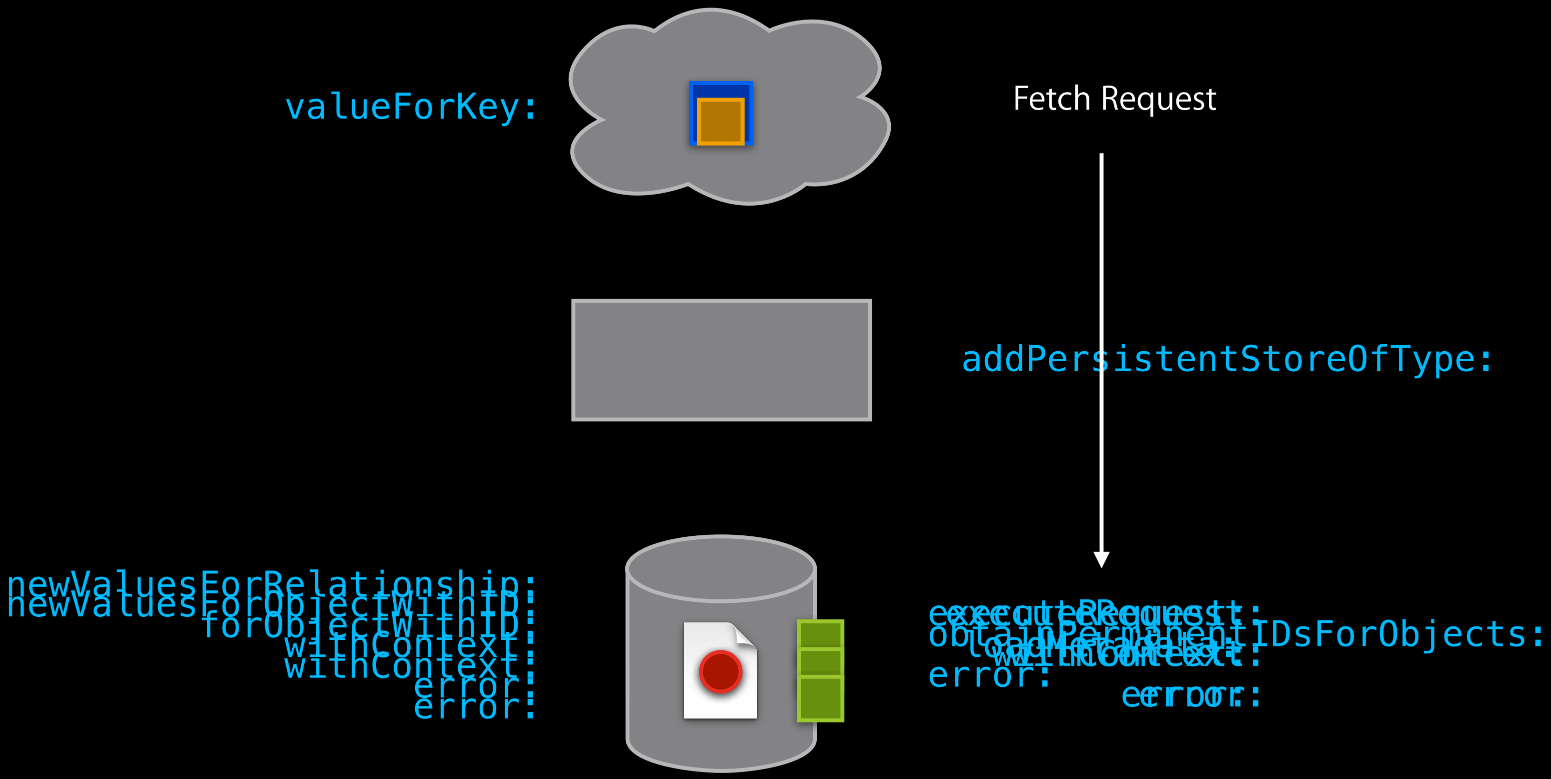
Incremental Store

- Talk to your data source in its own language
- Load only the data you need
- Supports faulting
- Flush unused data



Control Flow

How does it work?



NSIncrementalStoreNode

Data in a format Core Data can use

```
initWithObjectID:withValues:version:
valueForPropertyDescription:
```

Talking to the Store

NSPersistentStoreRequest and Friends

- New base class
- NSSaveChangesRequest
- Reparented NSFetchRequest

Requesting Data from the Store

NSFetchRequest

- Flags that affect results
- Flags that affect performance
- Graceful degradation

Implementation Details

- Object ID mapping APIs supplied
- Get managed objects from context

  `objectWithID:`

Integration Points

- SQL generator not included
  - Canned queries
- JSON provider in Foundation

General Design Tips

- Design to a specific schema
- Balance I/O and memory
    - Cache (API not provided)
- Better to talk to web services

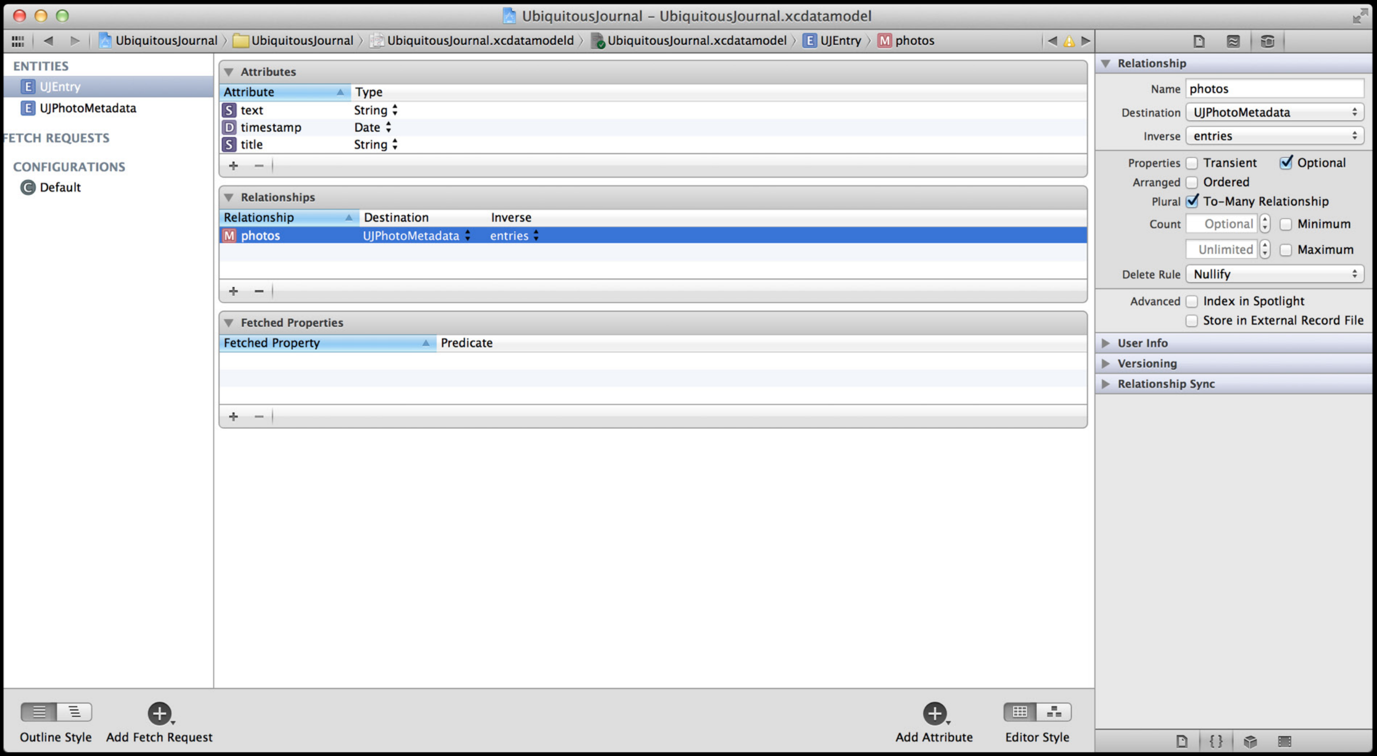
Developer Tools

Xcode 4

- New UI
- Optimized models
- Readable, diffable models
- Scalar accessors

New UI

Table View



UbiquitousJournal – UbiquitousJournal.xcdatamodel

UbiquitousJournal › UbiquitousJournal › UbiquitousJournal.xcdatamodeld › UbiquitousJournal.xcdatamodel › UJEntry › photos

ENTITIES
- E UJEntry
- E UJPhotoMetadata

FETCH REQUESTS

CONFIGURATIONS
- C Default

Attributes

Attribute	Type
S text	String
D timestamp	Date
S title	String

Relationships

Relationship	Destination	Inverse
M photos	UJPhotoMetadata	entries

Fetched Properties

Fetched Property	Predicate

Relationship

Name	photos
Destination	UJPhotoMetadata
Inverse	entries
Properties	☐ Transient ✓ Optional
Arranged	☐ Ordered
Plural	✓ To-Many Relationship
Count	Optional ☐ Minimum
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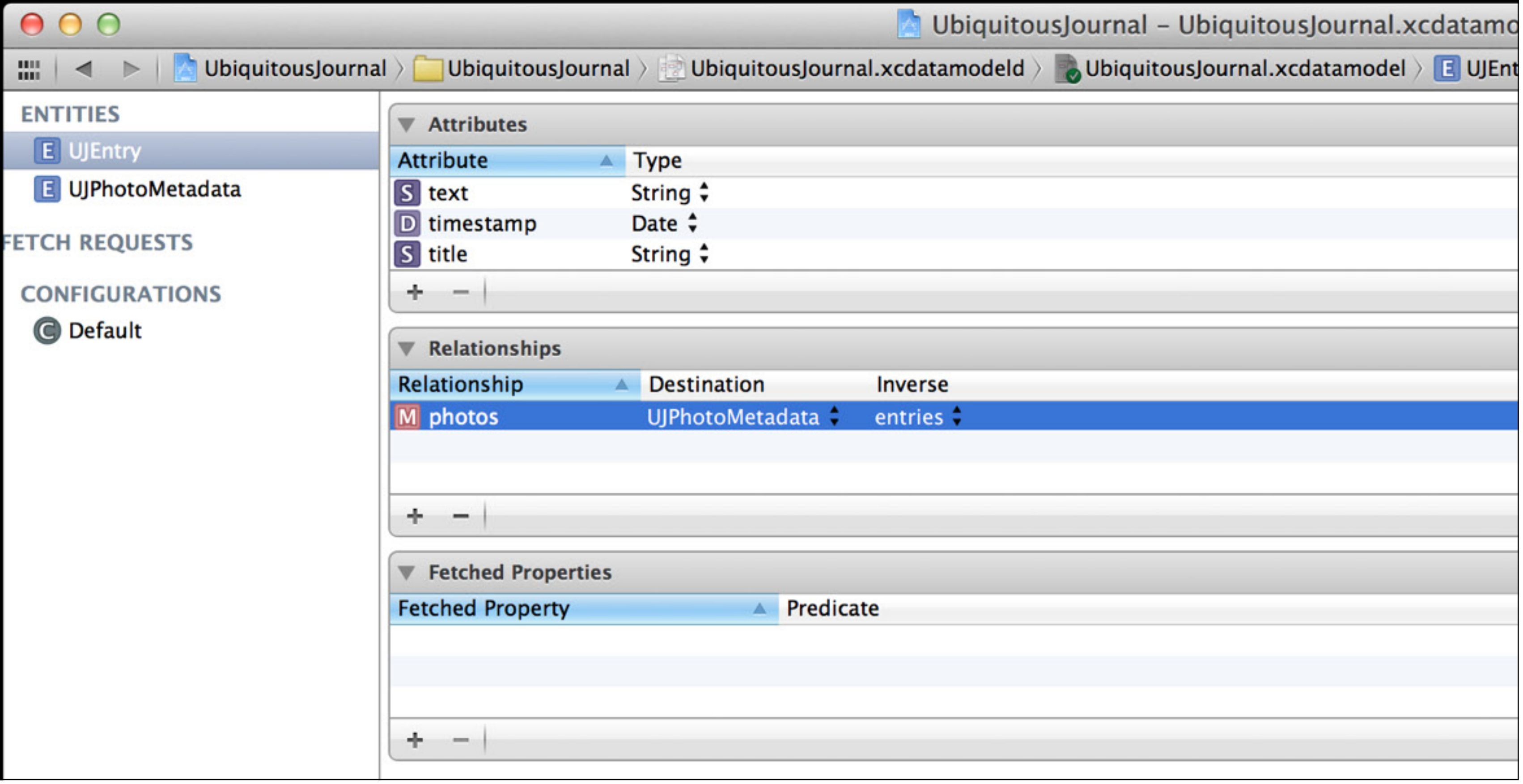
Delete Rule	Nullify
Advanced	☐ Index in Spotlight
	☐ Store in External Record File

New UI

Table View



UbiquitousJournal – UbiquitousJournal.xcdatamo
UbiquitousJournal 〉 UbiquitousJournal 〉 UbiquitousJournal.xcdatamodeld 〉 UbiquitousJournal.xcdatamodel 〉 UJEnt
ENTITIES
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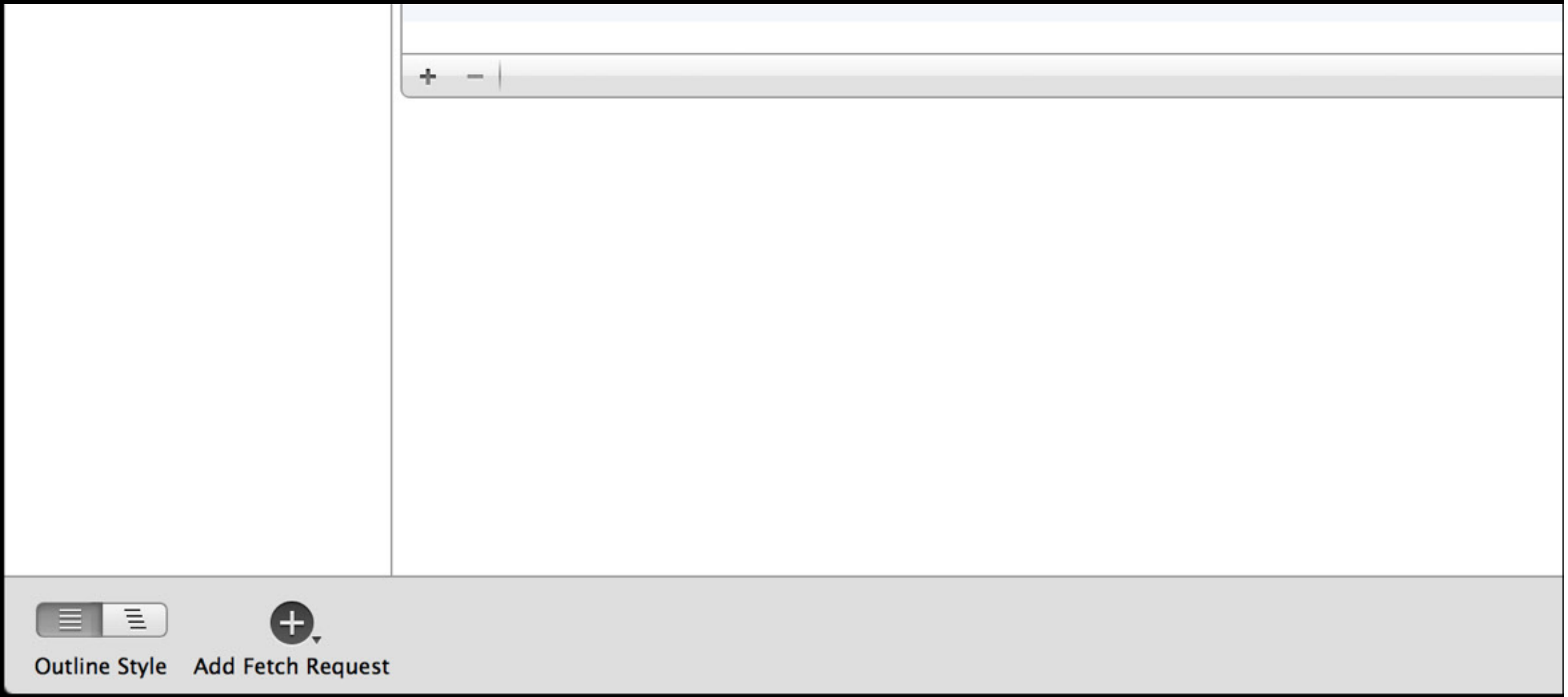
Attribute	Type
text	String
timestamp	Date
title	String

Relationship	Destination	Inverse
photos	UJPhotoMetadata	entries

Fetched Property	Predicate

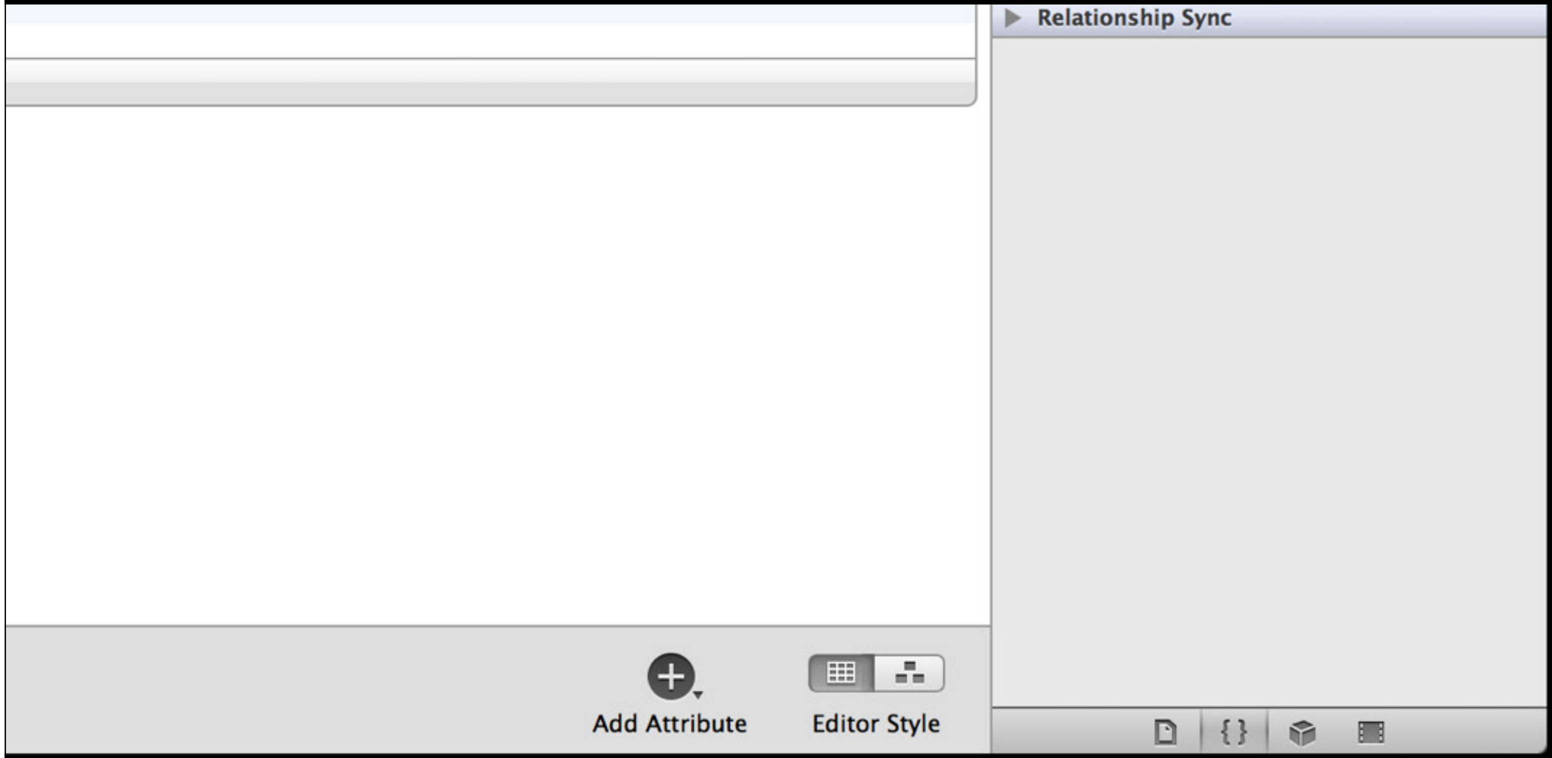
New UI

Table View



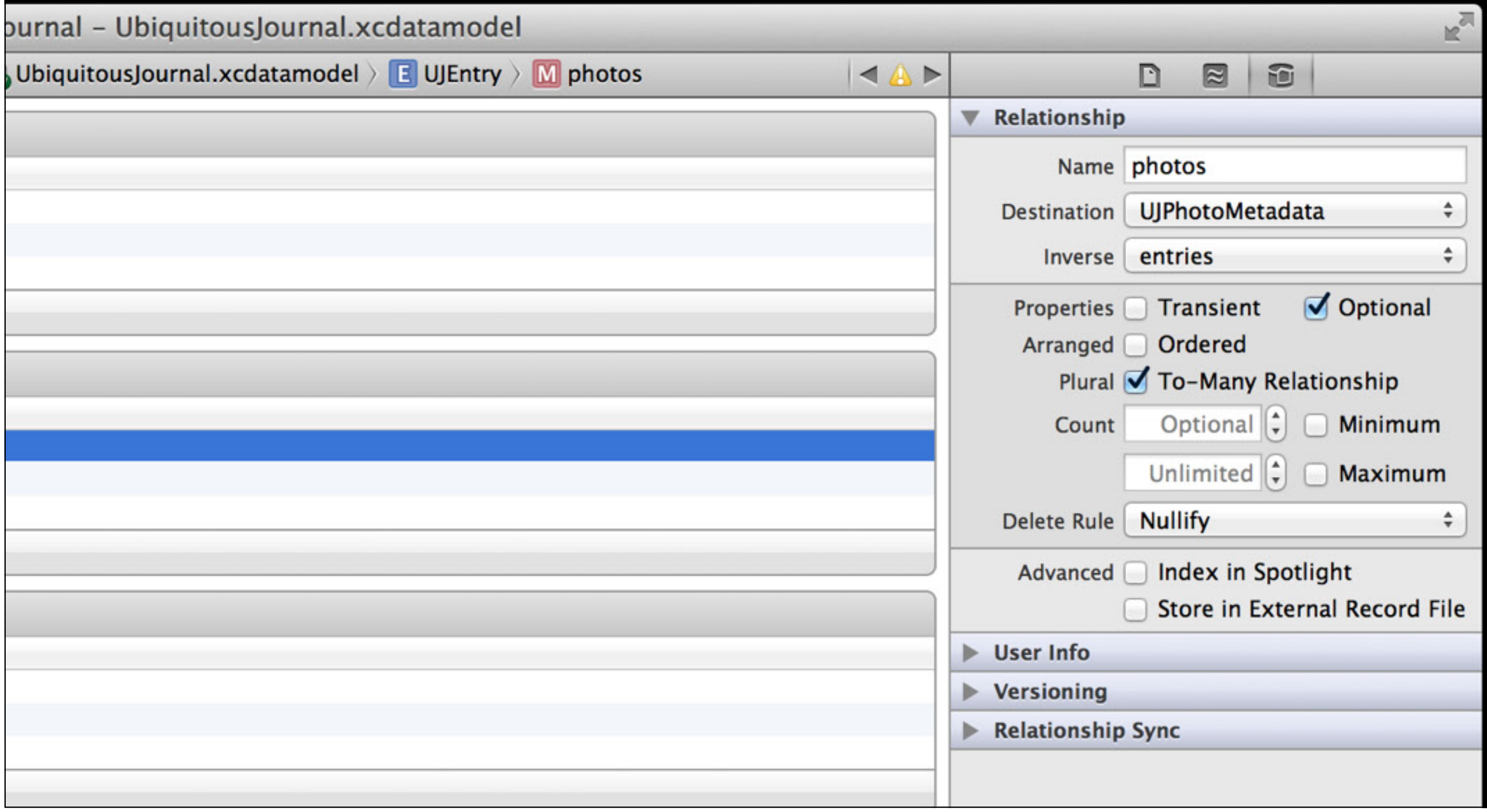
New UI

Table View



New UI

Table View



ournal – UbiquitousJournal.xcdatamodel

UbiquitousJournal.xcdatamodel 〉 E UJEntry 〉 M photos

Relationship

Name	photos
Destination	UJPhotoMetadata
Inverse	entries
Properties	☐ Transient ☑ Optional
Arranged	☐ Ordered
Plural	☑ To-Many Relationship
Count	Optional ☐ Minimum
	Unlimited ☐ Maximum
Delete Rule	Nullify
Advanced	☐ Index in Spotlight
	☐ Store in External Record File

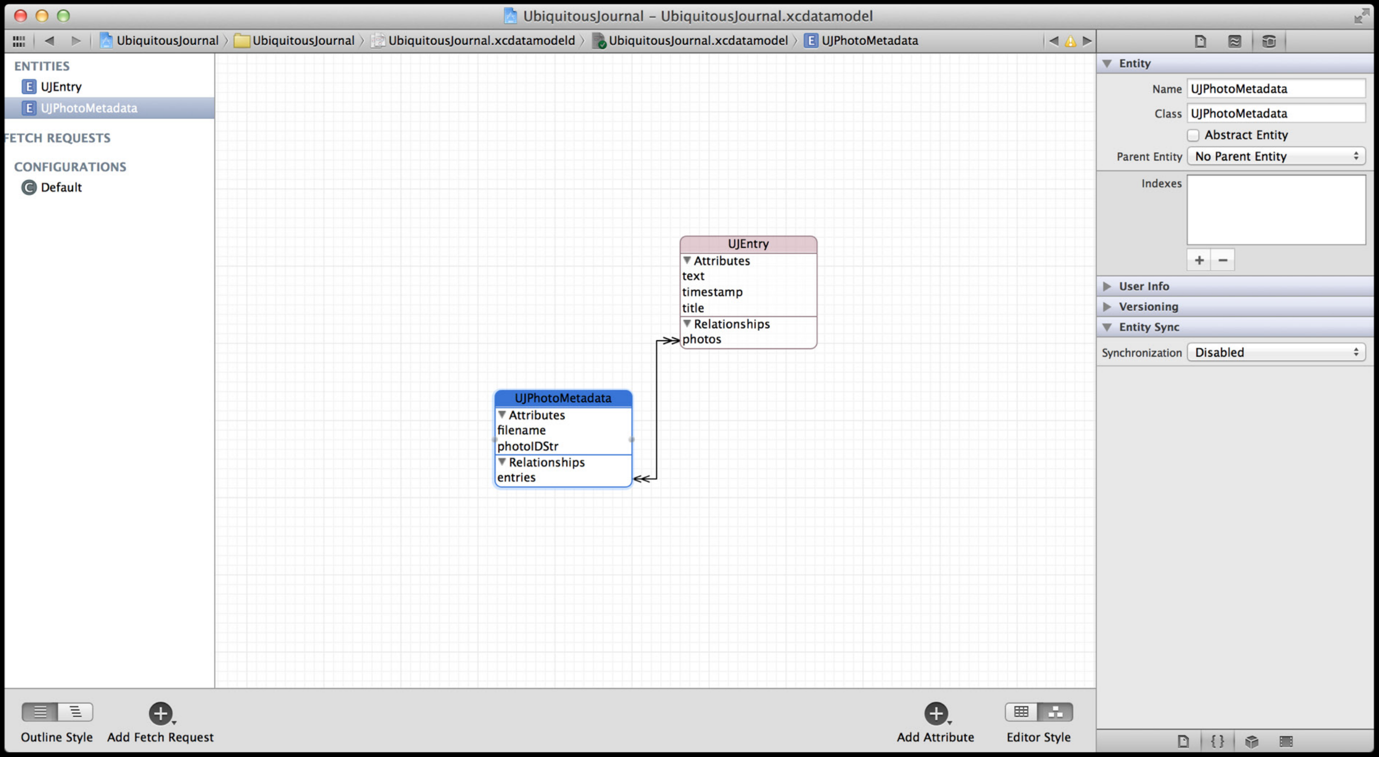
▶ User Info

▶ Versioning

▶ Relationship Sync

New UI

Diagram View



Name: UJPhotoMetadata
Class: UJPhotoMetadata
Abstract Entity
Parent Entity: No Parent Entity
Indexes
Synchronization: Disabled

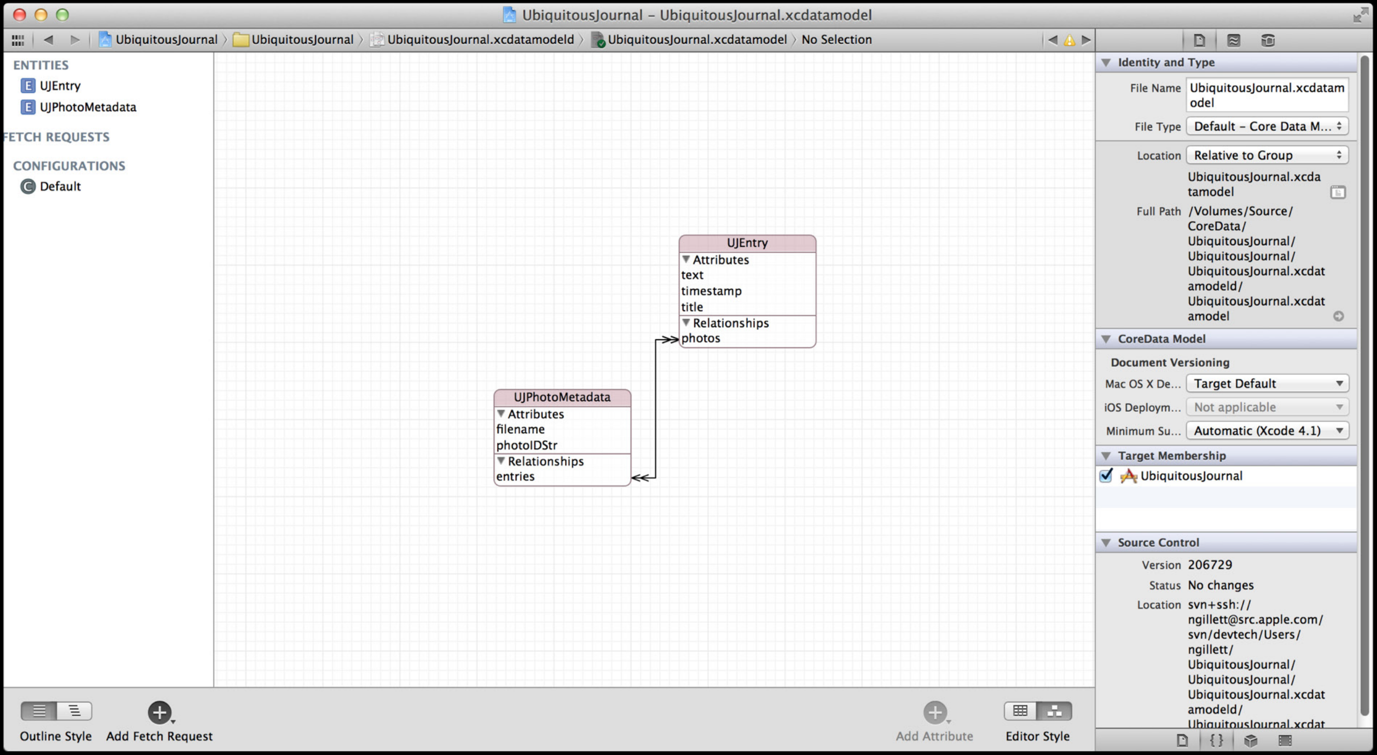
Optimized Model Format

- Speed up model loading
- Automatic with Xcode 4
- Lives in parallel with regular models

User Readable Xcode 4 Models

- Automatic in Xcode 4
  - Transparent upgrade from old format
- XML-based
- Work with your favorite diff tools

Readable Models


UbiquitousJournal – UbiquitousJournal.xcdatamodel

UbiquitousJournal 〉 UbiquitousJournal 〉 UbiquitousJournal.xcdatamodeld 〉 UbiquitousJournal.xcdatamodel 〉 No Selection

ENTITIES
- UJEntry
- UJPhotoMetadata

FETCH REQUESTS

CONFIGURATIONS
- Default

UJEntry
- Attributes: text, timestamp, title
- Relationships: photos

UJPhotoMetadata
- Attributes: filename, photoIDStr
- Relationships: entries

Identity and Type

File Name	UbiquitousJournal.xcdatamodel
File Type	Default – Core Data M...
Location	Relative to Group
	UbiquitousJournal.xcdatamodel
Full Path	/Volumes/Source/CoreData/UbiquitousJournal/UbiquitousJournal/UbiquitousJournal.xcdatamodeld/UbiquitousJournal.xcdatamodel

CoreData Model

Document Versioning

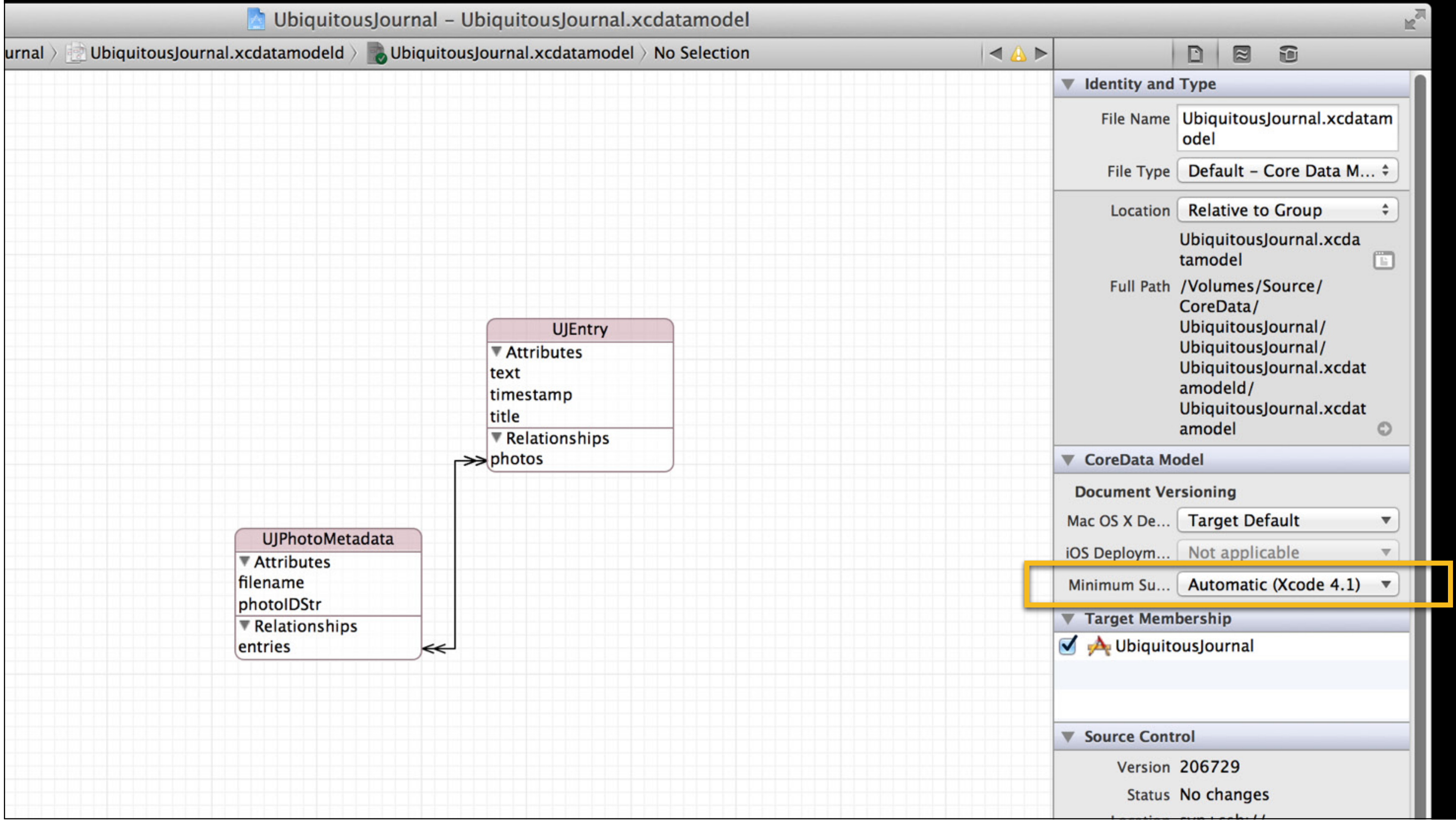
Mac OS X De...	Target Default
iOS Deploym...	Not applicable
Minimum Su...	Automatic (Xcode 4.1)

Target Membership
- [✓] UbiquitousJournal

Source Control

Version	206729
Status	No changes
Location	svn+ssh://ngillett@src.apple.com/svn/devtech/Users/ngillett/UbiquitousJournal/UbiquitousJournal/UbiquitousJournal.xcdatamodeld/UbiquitousJournal.xcdat

Readable Models



UbiquitousJournal – UbiquitousJournal.xcdatamodel

urnal 〉 UbiquitousJournal.xcdatamodeld 〉 UbiquitousJournal.xcdatamodel 〉 No Selection

UJEntry
▼ Attributes
text
timestamp
title
▼ Relationships
photos

UJPhotoMetadata
▼ Attributes
filename
photoIDStr
▼ Relationships
entries

▼ Identity and Type

File Name	UbiquitousJournal.xcdatamodel
File Type	Default – Core Data M...
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▼ CoreData Model

Document Versioning

Mac OS X De...	Target Default
iOS Deploym...	Not applicable
Minimum Su...	Automatic (Xcode 4.1)

▼ Target Membership

✓ UbiquitousJournal

▼ Source Control

Version	206729
Status	No changes

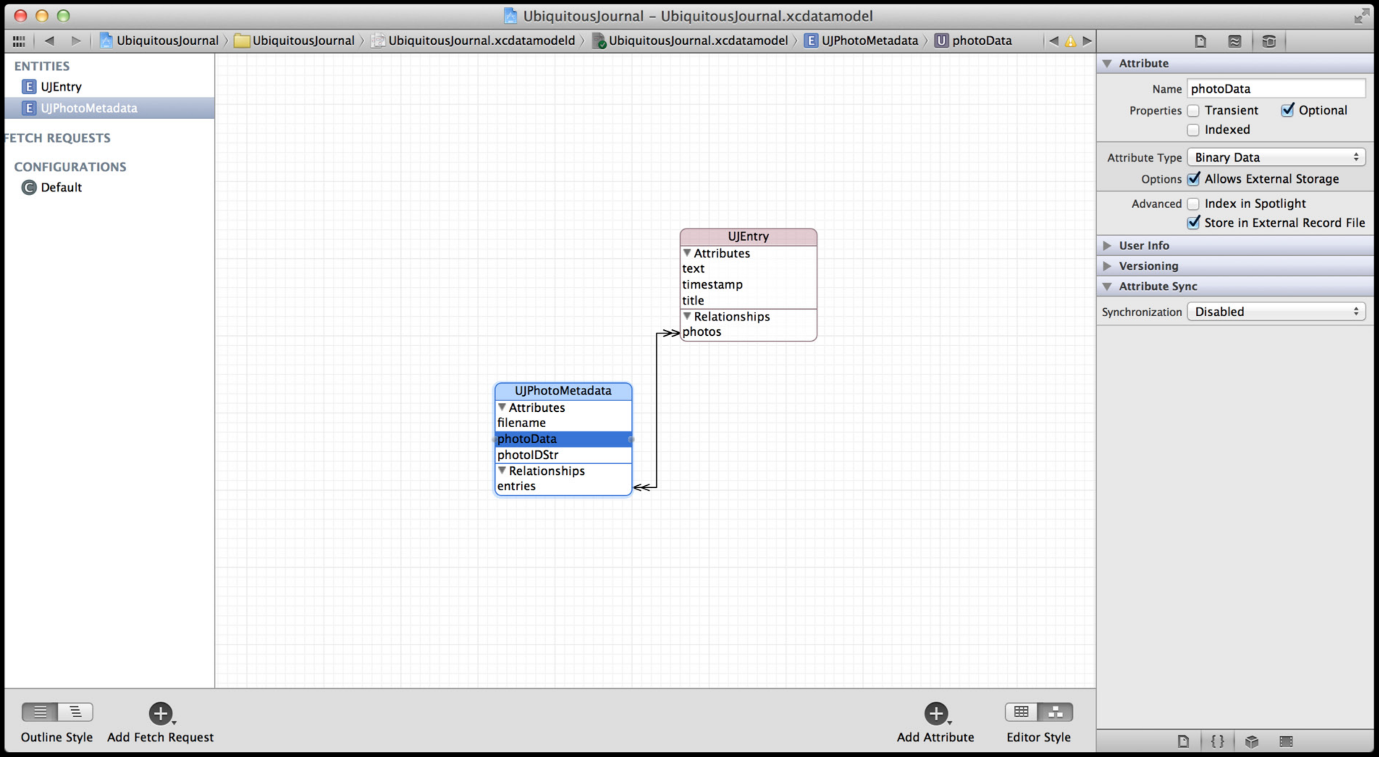
Scalar Accessors

- Avoid overhead of value object construction
- Checkbox during method creation

Automatic Reference Counting

- Makes memory management easier
- No need to implement or call retain and release
- Opt-in per project
  - New project templates enable by default
- Opt-out per file
- Go see the session or watch it on iTunes

External Binary Data



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UbiquitousJournal › UbiquitousJournal › UbiquitousJournal.xcdatamodeld › UbiquitousJournal.xcdatamodel › UJPhotoMetadata › photoData

ENTITIES
- UJEntry
- UJPhotoMetadata

FETCH REQUESTS

CONFIGURATIONS
- Default

UJEntry
- Attributes: text, timestamp, title
- Relationships: photos

UJPhotoMetadata
- Attributes: filename, photoData, photoIDStr
- Relationships: entries

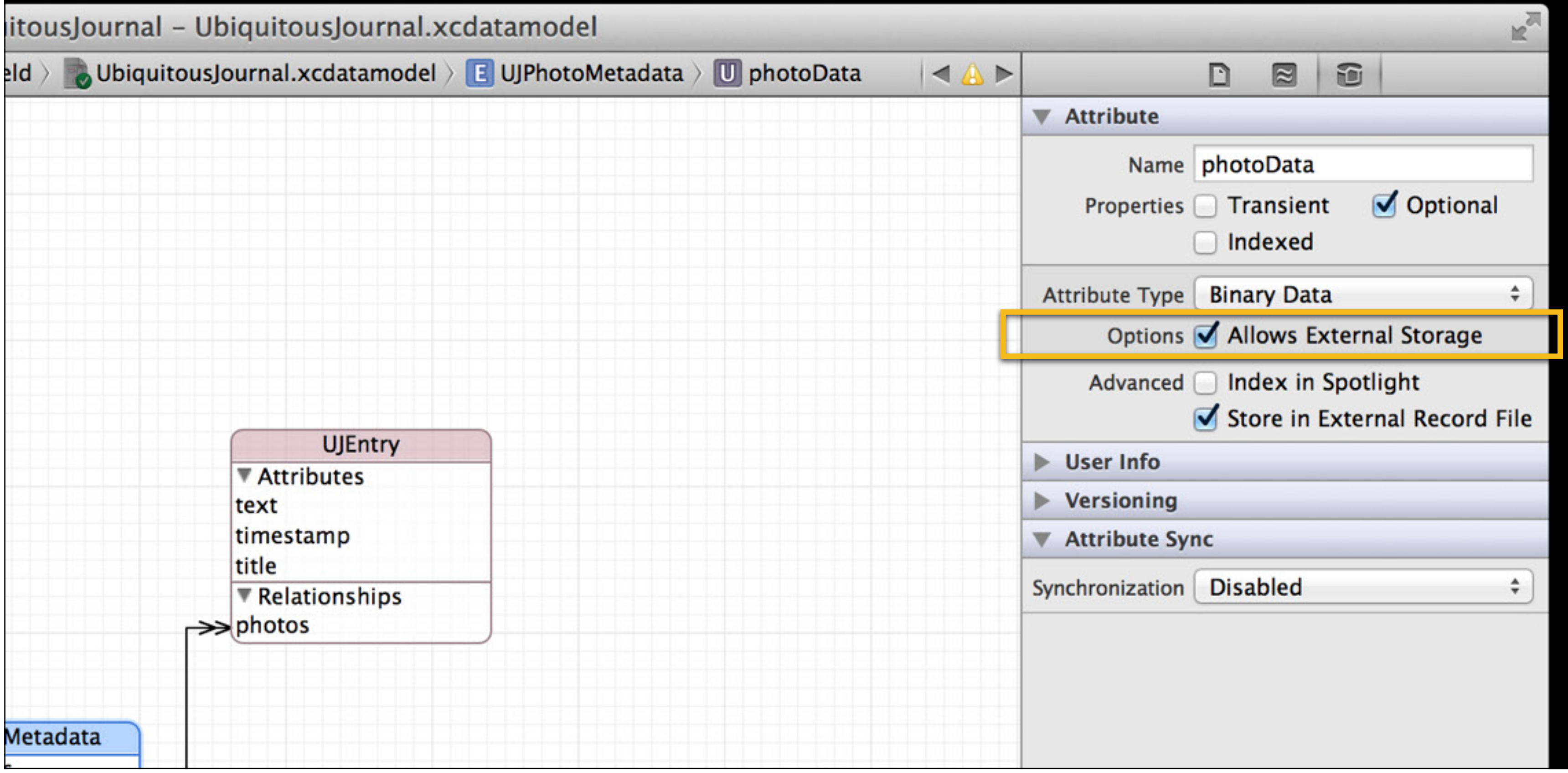
Attribute
- Name: photoData
- Properties: [ ] Transient [✓ Optional] [ ] Indexed
- Attribute Type: Binary Data
- Options: [✓ Allows External Storage]
- Advanced: [ ] Index in Spotlight [✓ Store in External Record File]

User Info

Versioning

Attribute Sync
- Synchronization: Disabled

External Binary Data



itousJournal – UbiquitousJournal.xcdatamodel

eld 〉 UbiquitousJournal.xcdatamodel 〉 E UJPhotoMetadata 〉 U photoData

Attribute

Name: photoData

Properties: [ ] Transient [✓] Optional [ ] Indexed

Attribute Type: Binary Data

Options: [✓] Allows External Storage

Advanced: [ ] Index in Spotlight [✓] Store in External Record File

User Info

Versioning

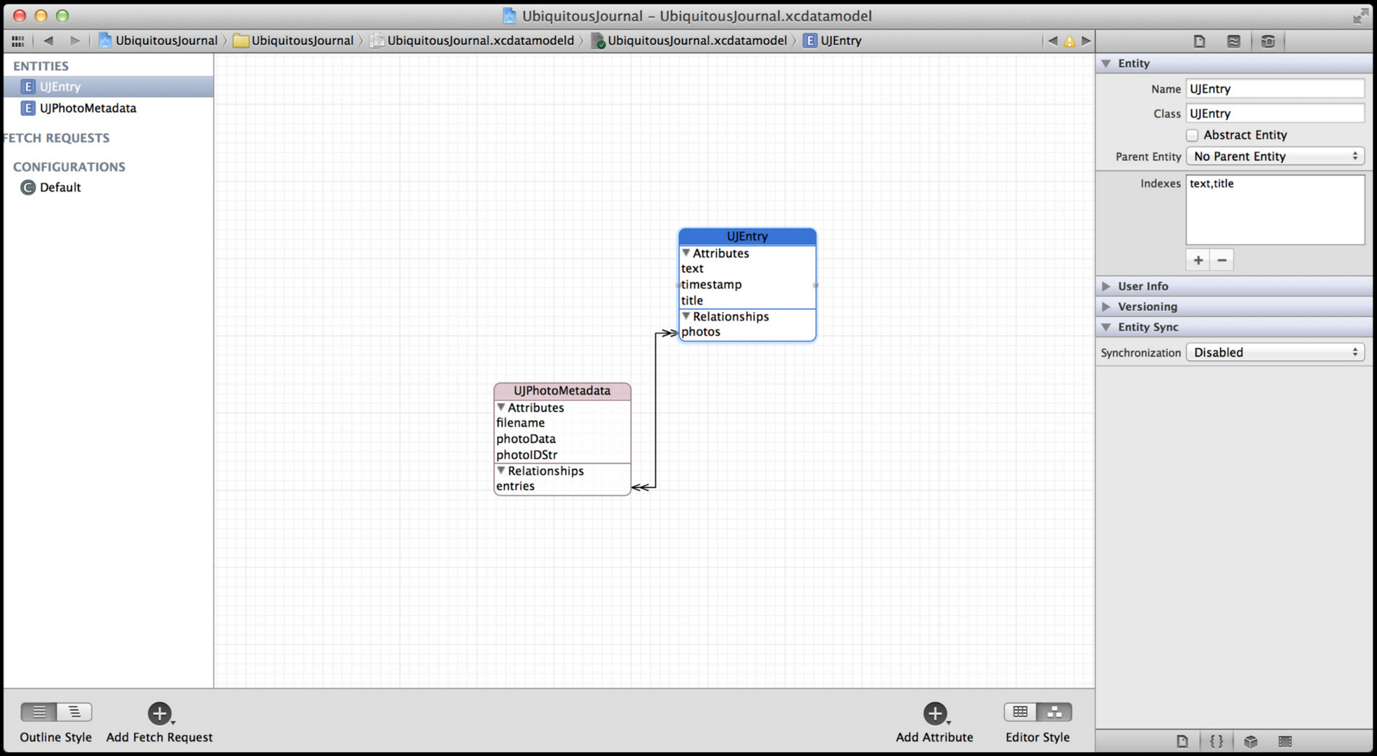
Attribute Sync

Synchronization: Disabled

Compound Indexes

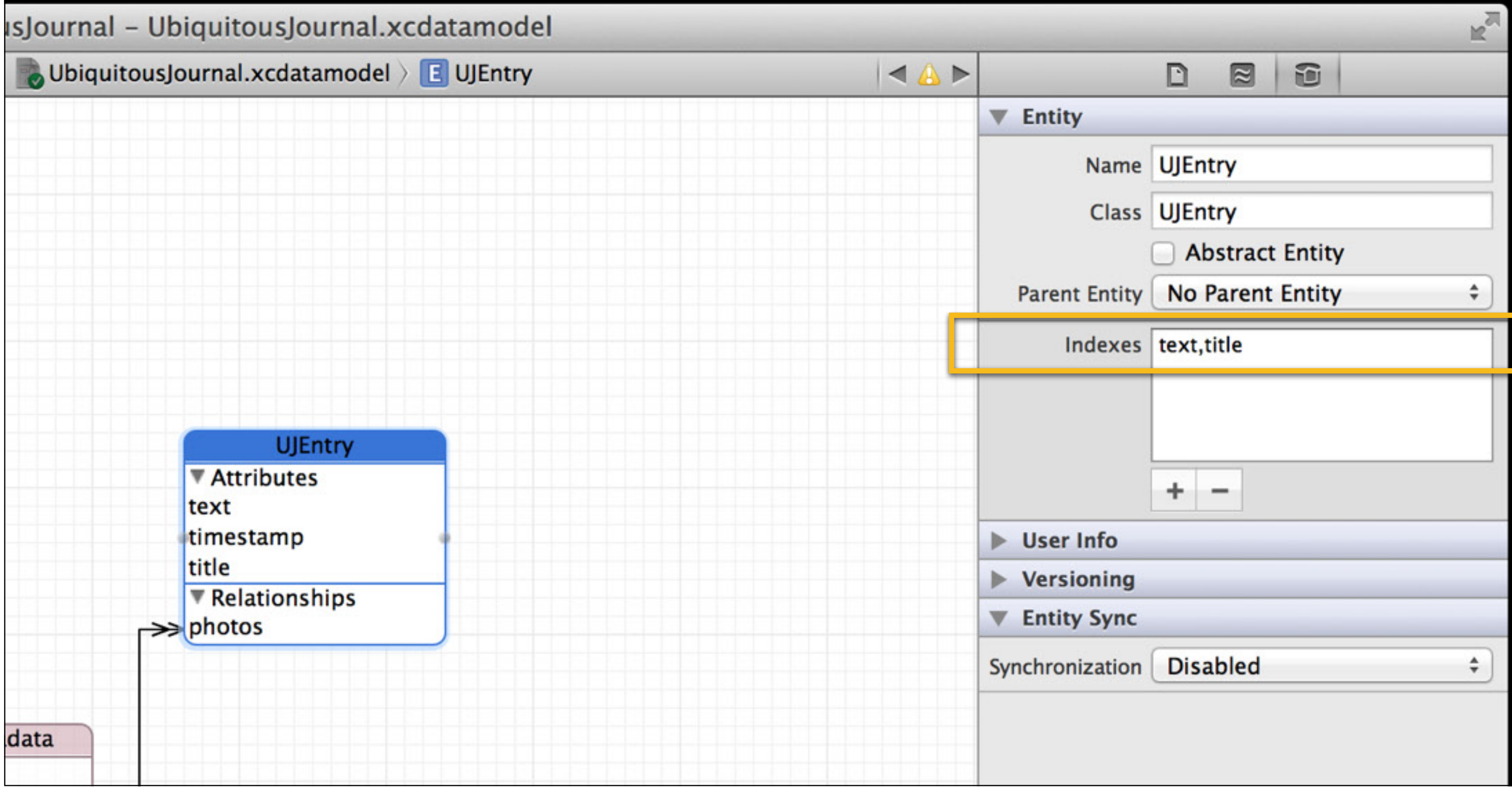
- Index across multiple properties
- Supported by SQLite store

Compound Indexes



Name UJEntry
Class UJEntry
Parent Entity No Parent Entity
Indexes text,title
Synchronization Disabled

Compound Indexes


sJournal – UbiquitousJournal.xcdatamodel

UbiquitousJournal.xcdatamodel 〉 E UJEntry

UJEntry
▼ Attributes
text
timestamp
title
▼ Relationships
photos

data

▼ Entity

Name	UJEntry
Class	UJEntry
	☐ Abstract Entity
Parent Entity	No Parent Entity
Indexes	text,title

▶ User Info
▶ Versioning
▼ Entity Sync

Synchronization: Disabled

Summary

- Amazing new iOS 5 features
  - iCloud
  - Documents
  - Data Protection
  - Incremental Stores
  - Ordered Relationships
- Feedback: forums, bug reports, enhancement requests

http://bugreport.apple.com

More Information

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Developer Tools Evangelist
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Core Data Documentation
Programming Guides, Examples, and Tutorials
http://developer.apple.com

Apple Developer Forums
http://devforums.apple.com

Related Sessions

What's New in Core Data on Mac OS X	Nob Hill Thursday 11:30AM
Storing Documents in iCloud Using iOS 5	Presidio Wednesday 3:15PM
Taking Advantage of File Coordination	Pacific Heights Tuesday 4:30PM
Introducing Automatic Reference Counting	Presidio Tuesday 4:30PM

Earlier Sessions

iCloud Storage Overview	Presidio Tuesday 11:30AM

Labs

Core Data Lab	Developer Tools Lab B Tuesday 4:30PM
Core Data Lab	Developer Tools Lab B Wednesday 4:30PM
Core Data Lab	Developer Tools Lab A Thursday 2:00PM

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