Core Data

CS 442: Mobile App Development
Michael Saelee <lee@iit.edu>
persistence framework
(not just an ORM, as non-relational backends are supported)
CD tracks an *object graph* (possibly disjoint), and manages its persistence automatically — supports on-demand loading & flushing
Does this via an explicitly referenced *context* — *all CD-managed objects* must be created in this context to be automatically persisted
Core Data class overview
CD-managed objects are of type `NSManagedObject`

= model instance / “entity”

≈ row in database table (for ORM)
- managed object may be a “fault” until data is needed
- when fault “fires”, object is hydrated from persistent store
how does Core Data know what entities we have, and what properties/relationships are defined for each entity?
**NSManagedObjectModel**

is used to describe our models/entities

≈ database schema
**NSManagedObjectModel** is a collection of per-entity **NSEntityDescription** objects

≈ table definition
can be created programmatically, but painful!
Choose a template for your new file:

- iOS
  - Cocoa Touch
  - C and C++
  - User Interface
  - Core Data
    - Core Data
    - Resource
    - Other
- Mac OS X
  - Cocoa
  - C and C++
  - User Interface
  - Core Data
  - Resource
  - Other

Data Model

A Core Data model file that allows you to use the design component of Xcode.
entity relationships
transient “fetched properties”
compiles to “.mom” file
- typically one .mom per app
- merging of multiple .moms automatically done (if needed)
let modelURL = Bundle.main.bundleURL().URLForResource("Cars", withExtension: "momd")!
let mom = NsManagedObjectModel(contentsOfURL: modelURL)
for entity in mom!.entities as [NSEntityDescription] {
    println(entity.name!)
    for property in entity.properties as [NSPropertyDescription] {
        print("- \(property.name)"")
        switch property {
            case let attribute as NSAttributeDescription:
                println(": \(attribute.attributeValueClassName!)")
            case let relationship as NSRelationshipDescription:
                println(" -> \(relationship.destinationEntity!.name!)")
        }
    }
}
recall: managed objects must be explicitly associated with a CD context
NSManagedObjectContext

- *all managed objects* live in one of these
  - a given managed object lives in *one and only one* MOC
    - MOC guarantees object uniqueness
MOC acts as a “scratchpad” for new/updated managed objects
— explicit save required for persistence
Managed Object Context

<table>
<thead>
<tr>
<th>Employee</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>Fred</td>
<td>90000</td>
</tr>
<tr>
<td>salary</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Employee</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>Nigel</td>
<td>60000</td>
</tr>
<tr>
<td>salary</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unsaved data

Save

Current data

<table>
<thead>
<tr>
<th>Employee</th>
<th>name</th>
<th>salary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fred</td>
<td>90000</td>
<td></td>
</tr>
<tr>
<td>Juli</td>
<td>97000</td>
<td></td>
</tr>
<tr>
<td>Nigel</td>
<td>50000</td>
<td></td>
</tr>
<tr>
<td>Tanya</td>
<td>56000</td>
<td></td>
</tr>
</tbody>
</table>
func applicationWillTerminate(application: UIApplication) {
  self.saveContext()
}

func saveContext () {
  if let moc = self.managedObjectContext {
    var error: NSError? = nil
    if moc.hasChanges && !moc.save(&error) {
      NSLog("Unresolved error \(error), \(error!.userInfo)")
      abort()
    }
  }
}
MOC also buys us free undo management

```swift
managedObjectContext.undoManager = NSUndoManager()  
```

**Undo Management**
- undo
- redo
- rollback
- save:
- hasChanges
note that a MOC is not thread-safe!

(not really a good idea anyway, to share a huge cache of mutable objects between threads)
MOC is *backing store agnostic*
i.e., it doesn’t matter what sort of storage mechanism is actually used for persistence
NSPersistentStoreCoordinator wraps and manages the backing store — almost never use use directly
supported persistent/disk stores are XML, binary, and SQLite; memory-based store is also available
SQLite is the only persistent store type that supports lazy/partial loading *(best scalability!)*
Recap:

**NSManagedObjects**, described by **NSEntityDescriptions**, live in a **NSManagedObjectContext**, which acts as a scratchpad for a **NSPersistentStoreCoordinator**, which persists an object graph to disk.
Essential Core Data Stack

- **Managed Object Context**: A collection of managed objects
- **Persistent Store Coordinator**: A collection of stores
- **Persistent Object Store**: A collection of object data
- **Store File**

**Managed Object Model**: A collection of entity descriptions
A Complex Core Data Setup
Putting this together in code ...
lazy var managedObjectModel: NSManagedObjectModel = {
    let modelURL = NSBundle.mainBundle().URLForResource("Model", withExtension: "momd")!
    return NSManagedObjectModel(contentsOfURL: modelURL)!
}()
lazy var persistentStoreCoordinator: NSPersistentStoreCoordinator? = {
    var coordinator: NSPersistentStoreCoordinator? =
        NSPersistentStoreCoordinator(managedObjectModel: self.managedObjectModel)
    let url = self.applicationDocumentsDirectory.URLByAppendingPathComponent("Model.sqlite")
    var error: NSError? = nil
    coordinator!.addPersistentStoreWithType(NSSQLiteStoreType,
        configuration: nil,
        URL: url,
        options: nil,
        error: &error)

    return coordinator
}()
lazy var managedObjectContext: NSManagedObjectContext? = {
    let coordinator = self.persistentStoreCoordinator
    var managedObjectContext = NSManagedObjectContext()
    managedObjectContext.persistentStoreCoordinator = coordinator
    return managedObjectContext
}()
don’t panic!

… all boilerplate code
typical setup: set up MOC in App Delegate & hand to root VC

```swift
func application(application: UIApplication, didFinishLaunchingWithOptions launchOptions: [NSObject: AnyObject]?) -> Bool {
    let navigationController = self.window!.rootViewController as UINavigationController
    let controller = navigationController.topViewController as MasterViewController
    controller.managedObjectContext = self.managedObjectContext
    return true
}
```
§ Working with Managed Objects
1. Creating them
2. Deleting them
3. Retrieving them
4. Managing large amounts of them
Creating managed objects
need two things:
- entity description — *what* type of object
- managed object context — *where* to put it
let entity = NSEntityDescription.entityForName("Person", inManagedObjectContext: moc)
let person = NSManagedObject(entity: entity!, insertIntoManagedObjectContext: moc)

let person = NSEntityDescription.insertNewObjectForEntityForName("Person",
inManagedObjectContext: moc)
access managed object properties via Key-Value Coding (KVC):

```swift
let person: NSManagedObject = ...

let name = person.valueForKey("name") as String

person.setValue("John Doe", forKey: "name")
```
navigate/manipulate object graph:

```
let newAddress = NSEntityDescription.insertNewObjectForEntityForName("Address", ...)  
newAddress.city = "Chicago"

person.mutableSetValueForKey("addresses").addObject(newAddress)

// OR

newAddress.setValue(person, forKey: "occupant")
```
let personName = address.valueForKeyPath("occupant.name") as String
let personCities = address.valueForKeyPath("occupant.addresses.city") as Set<String>
let numAddresses = address.valueForKeyPath("occupant.addresses.@count") as Int

the magic of KVC:
modifying properties of a managed object automatically informs the MOC of the changes! (via Key-Value Observing)

… MOC may then notify other interested parties (e.g., VCs)
NSNotificationCenter.defaultCenter().addObserver(self, selector: "mgdObjChange:", name: NSManagedObjectContextObjectsDidChangeNotification, object: moc)

func mgdObjChange (notification: NSNotification) {
    for obj in notification.userInfo?[NSUpdatedObjectsKey] as [NSManagedObject] {
        // do something with the changed obj (e.g., updated view)
    }
}
This syntax gets tiresome (and hard to read):

```
person.mutableSetValueForKey("addresses").addObject(newAddress)
```

Can prettify managed object access by subclassing `NSManagedObject`

(not always necessary, but nice)
import Foundation
import CoreData

class Address: NSManagedObject {

    @NSManaged var street: String
    @NSManaged var city: String
    @NSManaged var zip: String
    @NSManaged var occupant: Person
}

class Person: NSManagedObject {

    @NSManaged var name: String
    @NSManaged var email: String
    @NSManaged var addresses: NSSet

    func addAddress (address: Address) {
        mutableSetValueForKey("addresses").addObject(address)
    }
}
note: all vars are “NSManaged” — i.e., computed values! (managed by CD)
let john = NSEntityDescription.insertNewObjectForEntityForName("Person", inManagedObjectContext: moc) as Person
john.name = "John Doe"

let home = NSEntityDescription.insertNewObjectForEntityForName("Address", inManagedObjectContext: moc) as Address
home.city = "Chicago"
home.occupant = john

let work = NSEntityDescription.insertNewObjectForEntityForName("Address", inManagedObjectContext: moc) as Address
work.city = "Cupertino"
john.addAddress(work)

for addr in john.addresses as Set<Address> {
    println(addr.city)
}
let john = Person();

Beware!!!
managed objects must be associated with a managed object context!
Deleting managed objects

moc.deleteObject(person)

† may result in cascaded deletes!
Retrieving managed objects
NSFetchRequest
is used to query and retrieve objects from
the persistent store into an MOC

≈ database query / view
let fetchRequest = NSFetchRequest(entityName: "Person")

var error: NSError?
let fetchResults = moc.executeFetchRequest(fetchRequest, error: &error) as [Person]
let fetchRequest = NSFetchRequest(entityName: "Person")

fetchRequest.fetchBatchSize = 20 // no more than 20 returned at a time

var error: NSError?
let fetchResults = moc.executeFetchRequest(fetchRequest, error: &error) as [Person]
let fetchRequest = NSFetchRequest(entityName: "Person")

fetchRequest.fetchBatchSize = 20 // no more than 20 returned at a time

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

var error: NSError?
let fetchResults = moc.executeFetchRequest(fetchRequest, error: &error) as [Person]
let fetchRequest = NSFetchRequest(entityName: "Person")

fetchRequest.fetchBatchSize = 20  // no more than 20 returned at a time

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

let predicate = NSPredicate(format: "name contains %@", "ael")
fetchRequest.predicate = predicate  // e.g., matches "Michael" and "Raphael"

var error: NSError?
let fetchResults = moc.executeFetchRequest(fetchRequest, error: &error) as [Person]
**NSPredicate**

is used to define logical expressions
e.g., for use in fetch request (or, previously, to filter an array)
let requestFromTemplate = managedObjectModel.fetchRequestTemplateForName("MuscleCars")!
let results = moc.executeFetchRequest(requestFromTemplate, error: &error)
Managing large sets of fetched objects
e.g., in a tableview or navigation hierarchy
issues:

- mapping fetched results to cells and sections
- avoiding costly refetches (e.g., from DB)
- updating tableview when managed objects change (e.g., in another controller)
NSFetchedResultsController wraps fetch request, maps objects to cells, and manages a persistent cache.
let fetchRequest = NSFetchRequest(entityName: "Person")

let fetchedResultsController = NSFetchedResultsController(
    fetchRequest: fetchRequest,
    managedObjectContext: self.managedObjectContext!,
    sectionNameKeyPath: nil,
    cacheName: "Master")

fetchedResultsController.delegate = self // (view controller as delegate)
override func numberOfSectionsInTableView(tableView: UITableView) -> Int {
    return self.fetchedResultsController.sections?.count ?? 0
}

override func tableView(tableView: UITableView, numberOfRowsInSection section: Int) -> Int {
    let sectionInfo = self.fetchedResultsController.sections![section]
    return sectionInfo.numberOfObjects
}

override func tableView(tableView: UITableView, cellForRowAtIndexPath indexPath: NSIndexPath) -> UITableViewCell {
    let cell = tableView.dequeueReusableCellWithIdentifier("Cell", forIndexPath: indexPath)
    self.configureCell(cell, atIndexPath: indexPath)
    return cell
}

func configureCell(cell: UITableViewCell, atIndexPath indexPath: NSIndexPath) {
    let object = self.fetchedResultsController.objectAtIndexPath(indexPath) as NSManagedObject
    cell.textLabel!.text = object.valueForKey("name") as String
}
NSFetchedResultsController defines a delegate API for notifications of changes to associated fetch-results
@protocol NSFetchedResultsControllerDelegate
- (void)controllerWillChangeContent:(NSFetchedResultsController *)controller;

- (void)controller:(NSFetchedResultsController *)controller
didChangeObject:(id)anObject
    atIndexPath:(NSIndexPath *)indexPath
    forChangeType:(NSFetchedResultsChangeType)type
    newIndexPath:(NSIndexPath *)newIndexPath;

- (void)controllerDidChangeContent:(NSFetchedResultsController *)controller;
@end

(partial listing)
func controllerWillChangeContent(controller: NSFetchedResultsController) {
    self.tableView.beginUpdates()
}

func controller(controller: NSFetchedResultsController,
                 didChangeObject anObject: AnyObject,
                 atIndexPath indexPath: NSIndexPath?,
                 forChangeType type: NSFetchedResultsChangeType,
                 newIndexPath: NSIndexPath?) {
    switch type {
    case .Insert:
        tableView.insertRowsAtIndexPaths([newIndexPath!], withRowAnimation: .Fade)
    case .Delete:
        tableView.deleteRowsAtIndexPaths([indexPath!], withRowAnimation: .Fade)
    case .Update:
        self.configureCell(tableView.cellForRowAtIndexPath(indexPath)!,
                           atIndexPath: indexPath!)
    case .Move:
        tableView.deleteRowsAtIndexPaths([indexPath!], withRowAnimation: .Fade)
        tableView.insertRowsAtIndexPaths([newIndexPath!], withRowAnimation: .Fade)
    default:
        return
    }
}

func controllerDidChangeContent(controller: NSFetchedResultsController) {
    self.tableView.endUpdates()
}
§ Summary
**NSManagedObjects**, described by **NSEntityDescriptions**, live in a **NSManagedObjectContext**, which acts as a scratchpad for a **NSPersistentStoreCoordinator**, which persists an object graph to disk.
- core data adds overhead to persistence layer (e.g., SQLite)
- *but* also does caching & lazy-loading
- *and* adds uniquing, painless persistence, undo/redo + growing list of features
when to use?

- iOS 3.0+
- complex model objects
- dynamic & large object graph
- when able to use FRC with list views
when not to use?

- when portability (e.g., off iOS) is needed
- when small number of model objects
- when relational mapping is trivial (still debatable!)