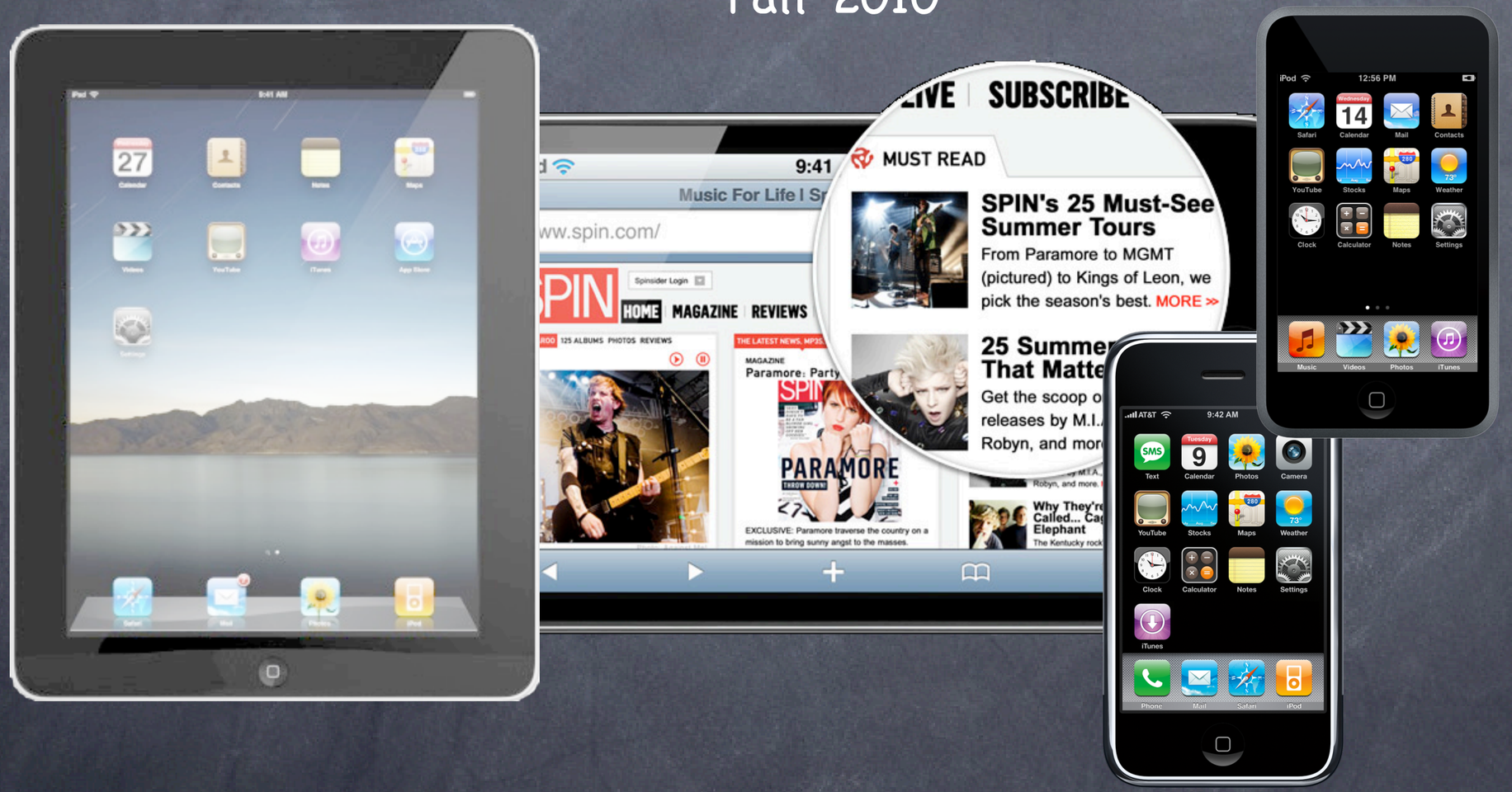
Stanford CS193p

Developing Applications for iPhone 4, iPod Touch, & iPad

Fall 2010



Today

- More Foundation Framework
  - NSArray, NSDictionary, NSSet
  - Enumeration
  - Property Lists
  - User Defaults
- More Objective-C
  - Allocating and Initializing objects
  - Memory Management
- Demo
  - NSDictionary / Enumeration
  - NSNumber
  - Introspection

Foundation Framework

- NSArray

  Ordered collection of objects.

  Immutable. That's right, you cannot add or remove objects to it once it's created.

  Important methods:

```
- (int)count;
- (id)objectAtIndex:(int)index;
- (void)makeObjectsPerformSelector:(SEL)aSelector;
- (NSArray *)sortedArrayUsingSelector:(SEL)aSelector;
- (id)lastObject;  // returns nil if there are no objects in the array (convenient)
```

- NSMutableArray

  Mutable version of `NSArray`.

```
- (void)addObject:(id)anObject;
- (void)insertObject:(id)anObject atIndex:(int)index;
- (void)removeObjectAtIndex:(int)index;
```

Foundation Framework

- NSDictionary

  Hash table. Look up objects using a key to get a value.

  Immutable. That's right, you cannot add or remove objects to it once it's created.

  Keys are objects which must implement `- (NSUInteger)hash` & `- (BOOL)isEqual:(NSObject *)obj`

  Keys are usually `NSString` objects.

  Important methods:

  ```
  - (int)count;
  - (id)objectForKey:(id)key;
  - (NSArray *)allKeys;
  - (NSArray *)allValues;
  ```

- NSMutableDictionary

  Mutable version of `NSDictionary`.

  ```
  - (void)setObject:(id)anObject forKey:(id)key;
  - (void)removeObjectForKey:(id)key;
  - (void)addEntriesFromDictionary:(NSDictionary *)otherDictionary;
  ```

Foundation Framework

- NSSet

  Unordered collection of objects.

  Immutable. That's right, you cannot add or remove objects to it once it's created.

  Important methods:

```
- (int)count;
- (BOOL)containsObject:(id)anObject;
- (id)anyObject;
- (void)makeObjectsPerformSelector:(SEL)aSelector;
- (id)member:(id)anObject;  // uses isEqual: and returns a matching object (if any)
```

- NSMutableSet

  Mutable version of NSSet.

```
- (void)addObject:(id)anObject;
- (void)removeObject:(id)anObject;
- (void)unionSet:(NSSet *)otherSet;
- (void)minusSet:(NSSet *)otherSet;
- (void)intersectSet:(NSSet *)otherSet;
```

Enumeration

- Looping through members of a collection in an efficient manner

  Language support using `for-in` (similar to Java)

  Example: `NSArray` of `NSString` objects

```
NSArray *myArray = ...;
for (NSString *string in myArray) {
    double value = [string doubleValue]; // crash here if string is not an NSString
}
```

  Example: `NSSet` of `id` (could just as easily be an `NSArray` of `id`)

```
NSSet *mySet = ...;
for (id obj in mySet) {
   // do something with obj, but make sure you don't send it a message it does not respond to
   if ([obj isKindOfClass:[NSString class]]) {
      // send NSString messages to obj with impunity
   }
}
```

Enumeration

- Looping through the keys or values of a dictionary

  Example:

```
NSDictionary *myDictionary = ...;
for (id key in myDictionary) {
    // do something with key here
    id value = [myDictionary objectForKey:key];
    // do something with value here
}
```

Property List

- The term "Property List" just means a collection of collections
  Specifically, it is any graph of objects containing only the following classes:
  `NSArray`, `NSDictionary`, `NSNumber`, `NSString`, `NSDate`, `NSData`
- An `NSArray` is a Property List if all its members are too
  So an `NSArray` of `NSString` is a Property List.
  So is an `NSArray` of `NSArray` as long as those `NSArray`'s members are Property Lists.
- An `NSDictionary` is one only if all keys and values are too
  An `NSArray` of `NSDictionary`s whose keys are `NSString`s and values are `NSNumber`s is one.
- Why define this term?
  Because the SDK has a number of methods which operate on Property Lists.
  Usually to read them from somewhere or write them out to somewhere.
  `[plist writeToFile:(NSString *)path atomically:(BOOL)]; // plist` is `NSArray` or `NSDictionary`

Other Foundation

- NSUserDefaults

Lightweight storage of Property Lists.

It's basically an NSDictionary that persists between launches of your application.

Not a full-on database, so only store small things like user preferences.

Read and write via a shared instance obtained via class method standardUserDefaults

```
[[NSUserDefaults standardUserDefaults] setArray:rvArray forKey:@"RecentlyViewed"];
```

Sample methods:

```
- (void)setDouble:(double)aDouble forKey:(NSString *)key;
- (NSInteger)integerForKey:(NSString *)key;  // NSInteger is a typedef to 32 or 64 bit int
- (void)setObject:(id)obj forKey:(NSString *)key; // obj must be a Property List
- (NSArray *)arrayForKey:(NSString *)key; // will return nil if value for key is not NSArray
```

Always remember to write the defaults out after each batch of changes!

```
[[NSUserDefaults standardUserDefaults] synchronize];
```

Creating Objects

- It is a two step operation to create an object in Objective-C
  - Allocating (almost always done with the `NSObject` class method `alloc`)
  - Initializing (done with a method that starts with the four letters `init`)
- `alloc` makes space in heap for the class's instance variables
  - Also sets them all to zero, so instance variables which are object pointers start out `nil`
- Each class has a "designated" `init`ializer method
  - `NSObject`'s is `init` (by convention, all `init` methods start with the four letters `init`)
  - When you subclass an object, you must call your superclass's designated initializer from your designated initializer (and make sure that it did not fail and return nil)
  - Your designated initializer should only take arguments that are required for the proper initialization of your class (i.e. if you can have sensible defaults for things, do it)
  - You can have other initializers (convenience initializers) which take other arguments, but those should always call your designated initializer (so that subclasses of yours will work properly)
  - All `init` methods should be typed (in their declaration) to return `id` (not statically typed)
  - Callers should statically type though, e.g., `MyObject *obj = [[MyObject alloc] init];`

Initializing Objects

- Example: A direct subclass of `NSObject`

  We use a sort of odd-looking construct to ensure that our superclass `init`ed properly.
  Our superclass's designated initializer can return `nil` if it failed to initialize.
  In that case, our subclass should return `nil` as well.
  Here are two versions. Either is okay.
  The one on the right looks weird because it assigns a value to `self`, but it's legal.

```
@implementation MyObject

- (id)init
{
    if ([super init]) {
        // initialize our subclass here
        return self;
    } else {
        return nil;
    }
}

@end
```

```
@implementation MyObject

- (id)init
{
    if (self = [super init]) {
        // initialize our subclass here
    }
    return self;
}

@end
```

Initializing Objects

- Example: A subclass of `CalculatorBrain` w/convenience initializer

  Imagine that we enhanced `CalculatorBrain` to have a list of "valid operations."
  We'll allow the list to be `nil` which means that all operations are valid.
  It might be nice to have a convenience initializer to set that array of operations.
  We'd want to have a `@property` to set the array as well, of course.
  Our designated initializer, though, is still `init` (the one we inherited from `NSObject`).

```
@implementation CalculatorBrain

- (id)initWithValidOperations:(NSArray *)anArray
{
    self = [self init];
    self.validOperations = anArray; // will do nothing if self == nil
    return self;
}

@end
```

  Note that we call our designated initializer on `self`, not `super`!
  We might add something to our designated initializer someday and we don't want to have to go back and change all of our convenience initializers too.
  Also, only our designated initializer should call our `super`'s designated initializer.

Initializing Objects

- Example: A subclass of `CalculatorBrain` w/designated initializer

  Let's change our requirements so that there must be at least one valid operation specified.
  Now we need a new designated (not convenience) initializer that forces that list to be non-empty.
  This is bad design, by the way. The other assumption about valid operations was better.

```
@implementation CalculatorBrain
- (id)initWithValidOperations:(NSArray *)anArray
{
    if (self = [super init]) {
        if ([anArray count]) {
            self.validOperations = anArray; // probably should also check validity
        } else {
            self = nil;
        }
    }
    return self;
}
- (id)init { return nil; } // ugh! but necessary since validOperations can't be nil
@end
```

Note that we are now calling our `super`'s designated initializer.

Initializing Objects

- Another example: A subclass of `UIView`

  `UIView`'s designated initializer is
  `- (id)initWithFrame:(CGRect)aRect;`
  Thus you cannot create a `UIView` without specifying an initial rectangle for it.

  Here's an example of creating a `UIView` (note the statically typed variable) ...
  `UIView *view = [[UIView alloc] initWithFrame:myFrame]; // no compiler warning (just like cast)`

Initializing Objects

- A Tale of Two Initializers

  Here are two different implementations of a subclass of UIView
  One keeps initWithFrame: as its designated initializer & adds a convenience initializer initToFit:

```
@implementation MyView
- (id)initWithFrame:(CGRect)aRect {
    if (self = [super initWithFrame:aRect]) {
        // initialize my subclass here
    }
    return self;
}
- (id)initToFit:(Shape *)aShape {
    CGRect fitRect = [MyView sizeForShape:aShape];
    return [self initWithFrame:fitRect];
}
@end
```

Initializing Objects

- A Tale of Two Initializers

  Here are two different implementations of a subclass of UIView
  One keeps initWithFrame: as its designated initializer & adds a convenience initializer initToFit:
  The other makes initToFit: the subclass's designated initializer (initWithFrame: is a convenience)

```
@implementation MyView
- (id)initWithFrame:(CGRect)aRect {
    if (self = [super initWithFrame:aRect]) {
        // initialize my subclass here
    }
    return self;
}
- (id)initToFit:(Shape *)aShape {
    CGRect fitRect = [MyView sizeForShape:aShape];
    return [self initWithFrame:fitRect];
}
@end
```

```
@implementation MyView
- (id)initWithFrame:(CGRect)aRect {
    return [self initToFit:[self defaultShape]];
}
- (id)initToFit:(Shape *)aShape {
    CGRect fitRect = [MyVew sizeForShape:aShape];
    if (self = [super initWithFrame:fitRect]) {
        // initialize my subclass here
    }
    return self;
}
@end
```

Initializing Objects

- A Tale of Two Initializers

  Here are two different implementations of a subclass of UIView
  One keeps initWithFrame: as its designated initializer & adds a convenience initializer initToFit:
  The other makes initToFit: the subclass's designated initializer (initWithFrame: is a convenience)

```
@implementation MyView
- (id)initWithFrame:(CGRect)aRect {
    if (self = [super initWithFrame:aRect]) {
        // initialize my subclass here
    }
    return self;
}
- (id)initToFit:(Shape *)aShape {
    CGRect fitRect = [MyView sizeForShape:aShape];
    return [self initWithFrame:fitRect];
}
@end
```

Note that both versions call UIView's designated initializer.

```
@implementation MyView
- (id)initWithFrame:(CGRect)aRect {
    return [self initToFit:[self defaultShape]];
}
- (id)initToFit:(Shape *)aShape {
    CGRect fitRect = [MyVew sizeForShape:aShape];
    if (self = [super initWithFrame:fitRect]) {
        // initialize my subclass here
    }
    return self;
}
@end
```

Getting Objects

- But alloc/init is not the only way to "get" an object
  Plenty of classes will give you an object if you ask for one.

```
NSString *newDisplay = [display.text stringByAppendingString:digit];
NSArray *keys = [dictionary allKeys];
NSString *lowerString = [string lowercaseString];
NSNumber *n = [NSNumber numberWithFloat:42.0];
NSDate *date = [NSDate date];  // returns the date/time right now
```

- Who frees the memory for all of these objects?
  Not just the above, but the `alloc`/`init` ones too.
- Sorry, no garbage collection
  Not on the iOS platforms anyway.
- The answer?
  Reference Counting

Reference Counting

- How does it work?
  Simple set of rules everyone must follow.
- You take ownership for an object you want to keep a pointer to
  Multiple owners for a given object is okay (common).
- When you're done with an object, you give up that ownership
  There's a way to take "temporary" ownership too.
- When no one claims ownership for an object, it gets deallocated
  After that point, your program will crash if that object gets sent a message!

Object Ownership

- When do you take ownership?

  You immediately own any object you get by sending a message starting with `new`, `alloc` or `copy`.
  The most common one of these is, of course, the combination of `alloc` followed by `init...`
  If you get an object from any other source you do not own it, but you can take ownership by sending it the `NSObject` message `retain`.

- So who owns an object you get not from `new`, `alloc` or `copy`?

  The object you got it from will own it temporarily until the call stack unwinds (more on this later).
  Or, the object you got it from owns it and is going to live long enough for you to `retain` it.

- How do you give up ownership when you are done?

  Send the object the `NSObject` message `release`.
  Do not send `release` to an object you do not own. This is very bad.

Temporary Ownership

- So how does this "temporary ownership" thing work?

  If you want to give someone an object with the "option" for them to take ownership of it,
  you must take ownership of it yourself, then send the object the message `autorelease`
  (or obtain a temporarily owned object from somewhere else, modify it, then give it away).

  Your ownership will "expire" at some future time (but not before the current event is finished).

  In the meantime, someone else can send `retain` to the object if they want to own it themselves.

- Best understood by example

```
- (Money *)showMeTheMoney:(double)amount {


}
```

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  In the meantime, someone else can send `retain` to the object if they want to own it themselves.

- Best understood by example

```
- (Money *)showMeTheMoney:(double)amount {
    Money *theMoney = [[Money alloc] init:amount];

}
```

We now own `theMoney`
because we got it using the method `alloc`.
We are responsible for sending it `release`.

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  In the meantime, someone else can send `retain` to the object if they want to own it themselves.

- Best understood by example

```
- (Money *)showMeTheMoney:(double)amount {
    Money *theMoney = [[Money alloc] init:amount];
    return theMoney;
}
```

Oops! We just `return`ed it.
We can't execute our responsibility to `release` it!

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  If you want to give someone an object with the "option" for them to take ownership of it,
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  Your ownership will "expire" at some future time (but not before the current event is finished).

  In the meantime, someone else can send `retain` to the object if they want to own it themselves.

- Best understood by example

```
- (Money *)showMeTheMoney:(double)amount {
    Money *theMoney = [[Money alloc] init:amount];
    [theMoney autorelease];
    return theMoney;
}
```

We have now executed our responsibility to `release`.
But it won't actually happen until the caller of this method
has had a chance to send `retain` to `theMoney` if they want.

Temporary Ownership

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  Your ownership will "expire" at some future time (but not before the current event is finished).

  In the meantime, someone else can send `retain` to the object if they want to own it themselves.

- Best understood by example

```
- (Money *)showMeTheMoney:(double)amount {
    Money *theMoney = [[Money alloc] init:amount];
    [theMoney autorelease];
    return theMoney;
}
```

- Caller

```
Money *myMoney = [bank showMeTheMoney:4500.00];
[myMoney retain];
```

Collections and autorelease

- Loading up an array or dictionary to return to a caller
  Imagine you have a method that returns an array of something.

```
@implementation MyObject

- (NSArray *)coolCats
{
    NSMutableArray *returnValue = [[NSMutableArray alloc] init];
    [returnValue addObject:@“Steve”];
    [returnValue addObject:@“Ankush”];
    [returnValue addObject:@“Sean”];
    return returnValue;
}

@end
```

Bad! We can't release this now.

Collections and autorelease

- Loading up an array or dictionary to return to a caller
  Imagine you have a method that returns an array of something.

```
@implementation MyObject

- (NSArray *)coolCats
{
    NSMutableArray *returnValue = [[NSMutableArray alloc] init];
    [returnValue addObject:@“Steve”];
    [returnValue addObject:@“Ankush”];
    [returnValue addObject:@“Sean”];
    [returnValue autorelease];
    return returnValue;
}

@end
```

All fixed!

Collections and autorelease

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    [returnValue autorelease];
    return returnValue;
}

@end
```

But there's a better way.
Get an autoreleased `NSMutableArray` in the first place.
Then fill it up and `return` it.

Collections and autorelease

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  Imagine you have a method that returns an array of something.

```
@implementation MyObject

- (NSArray *)coolCats
{
    NSMutableArray *returnValue = [[NSMutableArray alloc] init];
    [returnValue addObject:@“Steve”];
    [returnValue addObject:@“Ankush”];
    [returnValue addObject:@“Sean”];
    [returnValue autorelease];
    return returnValue;
}

@end
```

Instead of using alloc and init to create a NSMutableArray …

But there's a better way.
Get an autoreleased NSMutableArray in the first place.
Then fill it up and return it.

Collections and autorelease

- Loading up an array or dictionary to return to a caller
  Imagine you have a method that returns an array of something.

```
@implementation MyObject

- (NSArray *)coolCats
{
    NSMutableArray *returnValue = [NSMutableArray array];
    [returnValue addObject:@“Steve”];
    [returnValue addObject:@“Ankush”];
    [returnValue addObject:@“Sean”];
    [returnValue autorelease];
    return returnValue;
}

@end
```

We can use the method array
which returns an autoreleased NSMutableArray.

But there's a better way.
Get an autoreleased NSMutableArray in the first place.
Then fill it up and return it.

Collections and autorelease

- Loading up an array or dictionary to return to a caller
  Imagine you have a method that returns an array of something.

```
@implementation MyObject

- (NSArray *)coolCats
{
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    [returnValue addObject:@“Steve”];
    [returnValue addObject:@“Ankush”];
    [returnValue addObject:@“Sean”];

    return returnValue;
}

@end
```

Now we don't need (or want) this autorelease.

But there's a better way.
Get an autoreleased NSMutableArray in the first place.
Then fill it up and return it.

Collections and autorelease

- Loading up an array or dictionary to return to a caller
  Imagine you have a method that returns an array of something.

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@implementation MyObject

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    return returnValue;
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@end
```

Collections and autorelease

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    return returnValue;
}

@end
```

But there's an even better way!
Use collection classes "create with" methods.

Collections and autorelease

- Loading up an array or dictionary to return to a caller
  Imagine you have a method that returns an array of something.

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@implementation MyObject

- (NSArray *)coolCats
{
    NSMutableArray *returnValue = [NSMutableArray array];
    [returnValue addObject:@“Steve”];
    [returnValue addObject:@“Ankush”];
    [returnValue addObject:@“Sean”];
    return [NSArray arrayWithObjects:@“Steve”, @“Ankush”, @“Sean”, nil];
}

@end
```

Returns an autoreleased NSArray of the items.

But there's an even better way!
Use collection classes "create with" methods.

Collections and autorelease

- Loading up an array or dictionary to return to a caller
  Imagine you have a method that returns an array of something.

```
@implementation MyObject

- (NSArray *)coolCats
{
    return [NSArray arrayWithObjects:@“Steve”, @“Ankush”, @“Sean”, nil];
}

@end
```

Other convenient create with methods (all return autoreleased objects):

```
[NSString stringWithFormat:@“Meaning of %@ is %d”, @“life”, 42];
[NSDictionary dictionaryWithObjectsAndKeys:ankush, @“TA”, janestudent, @“Student”, nil];
[NSArray arrayWithContentsOfFile:(NSString *)path];
```

Other Ownership Rules

- Collections take ownership when an object is added to them
  `NSArray`, `NSDictionary`, `NSSet` (`NSDictionary` takes ownership of both keys and values).
  They then `release` ownership when an object is removed.
- Think of `@"string"` as `autoreleased`
  In reality, they are constants, so `retain` and `release` have no effect on them.
- `NSString` objects are usually sent `copy` rather than `retain`
  That gives you an immutable version of the string to hold on to.
  The method `copy` in `NSMutableString` returns an `NSString`, not an `NSMutableString`.
  Of course, you still `release` it when you are done with it.
- You should `release` an object as soon as possible
  In other words, on the next line of code after you've finished using it.
  The longer it stays owned, the more a reader of your code wonders what its going to be used for

Deallocation

- What happens when the last owner calls `release`?

  A special method, `dealloc`, is called on the object & the object's memory is returned to the heap.
  After this happens, sending a message to the object will crash your program.

- You should override `dealloc` in your classes, but NEVER call it!

  It only gets called by `release` when the last owner has `released` the object.
  The one exception about calling it is that you must call `[super dealloc]` in your `dealloc`.
  Besides that, if you call it in your homework assignments, you will be soundly reproofed.

- Example

```
- (void)dealloc
{
    [brain release];
    [otherObjectInstanceVariable release];
    [super dealloc];
}
```

@property

- What about `@property`?
  It's important to understand who owns an object returned from a getter or passed to a setter.
- Getter methods usually return instance variables directly
  But for callers this is practically no different than return an `autoreleased` object.
  That's because we assume the implementor of the getter isn't going to be `released` immediately.
  So the object we got from the getter will be around long enough for us to `retain` it or not.
- Consider `UILabel`'s text property in our Calculator

```
display.text = [display.text stringByAppendingString:digit];
```

This comes back still owned by `display` (the `UILabel`).
We don't `retain` it because we are not going to keep it.
We're just going to use it to acquire a different `NSString` from `stringByAppendingString:`

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display.text = [display.text stringByAppendingString:digit];
```

This comes back still owned by `display` (the `UILabel`).
We don't `retain` it because we are not going to keep it.
We're just going to use it to acquire a different `NSString` from `stringByAppendingString:`

This is the `NSString` we acquired.
It comes back `autoreleased`.
We're not going to `retain` this one either because we're just going to pass it on to `display`'s `text` property setter method.

@property

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- Getter methods usually return instance variables directly
  But for callers this is practically no different than return an autoreleased object.
  That's because we assume the implementor of the getter isn't going to be released immediately.
  So the object we got from the getter will be around long enough for us to retain it or not.
- Consider UILabel's text property in our Calculator

```
display.text = [display.text stringByAppendingString:digit];
```

This is the NSString we acquired.
It comes back autoreleased.
We're not going to retain this one either
because we're just going to pass it on to
display's text property setter method.

@property

- What about `@property` setter methods?
  Imagine setting an instance variable via a property.
  Did we `retain` that object that we just set to be one of our instance variables?
  We certainly should and we certainly could in our implementation of our setter.
  But what if we use `@synthesize` to implement our setter? Is `retain` automatically sent? No.
- There are three options for setters made by `@synthesize`

```
@property (retain) NSArray *myArrayProperty;
@property (copy) NSString *someNameProperty;
@property (assign) id delegate;
```

- The first two are straightforward, the third requires thought
  The third `(assign)` means that neither `retain` nor `copy` is sent to the object passed to the setter.
  This means that if that object is `released` by all other owners, we'll have a bad pointer.
  So we only use `assign` if the passed object essentially owns the object with the property.
  Best example: a Controller and its Views (because a View should never outlive its Controller).
  A View can have a property (`delegate` is very common) which is `assigned` to its Controller.

@property

- Example

```
@property (retain) NSString *name;
```

`@synthesize` will create a setter equivalent to this …

```
- (void)setName:(NSString *)aString
{
    [name release];
    name = [aString retain];
}
```

Note that `@synthesize` will `release` the previous object (if any, could be `nil`) before setting and `retain`ing the new one.

@property

- Example

```
@property (copy) NSString *name;

@synthesize will create a setter equivalent to this ...

- (void)setName:(NSString *)aString
{
    [name release];
    name = [aString copy];
}
```

Still release-ing before copying.

@property

- Example

```
@property (assign) NSString *name;

@synthesize will create a setter equivalent to this ...

- (void)setName:(NSString *)aString
{
    name = aString;
}
```

No `release` here because we never `retain` or `copy`.

Next Time

- View Hierarchy and Custom Views
  Breaking out from just buttons and text fields
- Application Lifecycle
  From creation through event-handling and delegate method calling
- View Controller Lifecycle
  Same thing, but for UIViewControllers
- Navigation Controllers
  Building multi-screen applications

Demo

- Collector
  Collects strings or numbers touched on in the user interface
  Reports how many of each happened
- Model
  `Collector`
- View
  Bunch of random buttons
- Controller
  `CollectorViewController`
- Watch for ...
  How we use `NSNumber` to wrap primitives (`int`s in this case)
  How we use introspection to have an `NSDictionary` with object of different classes as keys
  Using properties (with or without associated instance variables)