Announcements

- **Lab 1 is due on Wednesday by midnight**
- **Email it to cse436ta@gmail.com**
  - LastName-Lab1.zip
- **Delete your labs from the Whitaker Macs**
- **Labs 2 will be posted by Wednesday**
  - Lab 2 due Monday Feb 9th
- **TA hours are now posted on the course website**

Today's Topics

- **Foundation Classes (from last class)**
- **Selectors**
- **Creating Custom Classes**
- **Object Lifecycle**
- **Autorelease**
- **Objective-C Properties**

Foundation Classes

Foundation Framework

- Value and collection classes
- User defaults
- Archiving
- Notifications
- Undo manager
- Tasks, timers, threads
- File system, pipes, I/O, bundles

NSObject

- **Root class**
- **Implements many basics**
  - Memory management
  - Introspection
  - Object equality

NSString

- **General-purpose Unicode string support**
  - Unicode is a coding system which represents all of the world's languages
- **Consistently used throughout Cocoa Touch instead of "char *"**
- **The most commonly used class**
- **Easy to support any language in the world with Cocoa**

String Constants

- **In C constant strings are**
  - "simple"
- **In ObjC, constant strings are**
  - @"just as simple"
- **Constant strings are**

```
NSString *aString = @"Hello World!";
```


Format Strings

- **Similar to printf, but with %@ added for objects**

```
NSString *aString = @"Johnny";
NSString *log = [NSString stringWithFormat: @"It's '%@'", aString];
```

- **log would be set to**
  - It's 'Johnny'
- **Also used for logging**

```
NSLog(@"I am a %@, I have %d items", [array className], [array count]);
```

- **would log something like:**
  - I am a NSArray, I have 5 items

NSString

- **Often ask an existing string for a new string with modifications**

-(NSString *)stringByAppendingString:(NSString *)string;
-(NSString *)stringByAppendingFormat:(NSString *)string;

-(NSString *)stringByDeletingPathComponent;

- **Example:**

```
NSString *myString = @"Hello";
NSString *fullString;
fullString = [myString stringByAppendingString:@" world!"];
```

- **fullString would be set to**
  - Hello world!

NSString

- **Common NSString methods**

```
-(BOOL)isEqualToString:(NSString *)string;
-(BOOL)hasPrefix:(NSString *)string;
-(int)intValue;
-(double)doubleValue;
```

- **Example:**

```
NSString *myString = @"Hello";
NSString *otherString = @"449";
if ([myString hasPrefix:@"He"]) {
  // will make it here
}
if ([otherString intValue] > 500) {
  // won't make it here
}
```

NSMutableString

- subclasses NSString
- Allows a string to be modified
- Common NSMutableString methods

```
+ (id)string;
- (void)appendString:(NSString *)string;
- (void)appendFormat:(NSString *)format, ...;
```

```
NSMutableString *newString = [NSMutableString string];
[newString appendString:@"Hi"];
[newString appendFormat:@", my favorite number is: %d",[self favoriteNumber]];
```


Collections

- Array - ordered collection of objects
- Dictionary - collection of key-value pairs
- Set - unordered collection of unique objects

- Common enumeration mechanism
- Immutable and mutable versions
- Immutable collections can be shared without side effect
  - Prevents unexpected changes
  - Mutable objects typically carry a performance overhead

NSArray

- **Common NSArray methods**

```
+ arrayWithObjects:(id)firstObj, ...; // nil terminated!!!
 -(unsigned)count;
-(id)objectAtIndex:(unsigned)index;
 -(unsigned)indexOfObject:(id)object;
```

- **NSNotFound returned for index if not found**

```
NSArray *array = [NSArray arrayWithObjects:@"Red", @"Blue",
    @"Green",nil];

if ([array indexOfObject:@"Purple"] == NSNotFound) {
    NSLog (@"No color purple");
}
```


NSMutableArray

- **NSMutableArray subclasses NSArray**
  - So, everything in NSArray
- **Common NSMutableArray Methods**

```
+ (NSMutableArray *)array;
- (void)addObject:(id)object;
- (void)removeObject:(id)object;
- (void)removeAllObjects;
- (void)insertObject:(id)object atIndex:(unsigned)index;
```

```
NSMutableArray *array = [NSMutableArray array];
[array addObject:@"Red"];
[array addObject:@"Green"];
[array addObject:@"Blue"];
[array removeObjectAtIndex:1];
```

NSDictionary

- **Common NSDictionary methods**

```
+ dictionaryWithObjectsAndKeys:(id)firstObject, ...;
-(unsigned)count;
-(id)objectForKey:(id)key;
```

- **nil returned if no object found for given key**

```
NSDictionary *colors =
 [NSDictionary dictionaryWithObjectsAndKeys:@"Red", @"Color 1",
   @"Green", @"Color 2", @"Blue", @"Color 3", nil];

NSString *firstColor = [colors objectForKey:@"Color 1"];

if ([colors objectForKey:@"Color 8"]) {
  // won't make it here
}
```


NSMutableDictionary

- **NSMutableDictionary subclasses NSDictionary**
- **Common NSMutableDictionary methods**

```
+ (NSMutableDictionary *)dictionary;
- (void)setObject:(id)object forKey:(id) key;
- (void)removeObjectForKey:(id)key;
- (void) removeAllObjects;
```

```
NSMutableDictionary *colors = [NSMutableDictionary dictionary];
[colors setObject:@"Orange" forKey:@"HighlightColor"];
```

NSSet

- Unordered collection of distinct objects
- Common NSSet methods

```
+ setWithObjects:(id)firstObj, ...; // nil terminated
- (unsigned)count;
- (BOOL)containsObject:(id)object;
```


NSMutableSet

- NSMutableSet subclasses NSSet
- Common NSMutableSet methods

```
+ (NSMutableSet *)set;
- (void)addObject:(id)object;
- (void)removeObject:(id)object;
- (void)removeAllObjects;
- (void)intersectSet:(NSSet *)otherSet;
- (void)minusSet:(NSSet *)otherSet;
```

Enumeration

- **Consistent way of enumerating over objects in collections**
- **Use with NSArray, NSDictionary, NSSet, etc.**

```
NSArray *array = ... ; // assume an array of People objects

// old school
 Person *person;
int count = [array count];
for (i = 0; i < count; i++) {
  person = [array objectAtIndex:i];
  NSLog([person description]);
}

// new school
for (Person *person in array) {
  NSLog([person description]);
}
```


Other Classes

- **NSData / NSMutableData**
  - Arbitrary sets of bytes
- **NSDate / NSCalendarDate**
  - Times and dates

More ObjC Info?

- http://developer.apple.com/documentation/Cocoa/Conceptual/ObjectiveC
- Concepts in Objective C are applicable to any other OOP language

Methods and Selectors

Terminology

- **Message expression**

  [receiver method: argument]

- **Message**

  [receiver method: argument]

- **Selector**

  [receiver method: argument]

- **Method**

  The code selected by a message

Methods, Messages, Selectors

- **Method**
  - Behavior associated with an object

```
-(NSString *)name
{
    // Implementation
}
-(void)setName:(NSString *)name
{
   //Implementation
}
```

Methods, Selectors, Messages

- **Selector**
  - Name for referring to a method
  - Includes colons to indicate arguments
  - Doesn't actually include arguments or indicate types

```
SEL mySelector = @selector(name);

SEL anotherSelector =@selector(setName:);

SEL lastSelector = @selector(doStuff:withThing:andThing:);
```


Methods, Messages, Selectors

- **Message**
  - The act of performing a selector on an object
  - With arguments, if necessary

```
NSString *name = [myPerson name];

[myPerson setName:@"New Name"];
```

Selectors identify methods by name

- **A selector has type SEL**

```
SEL action = [button action];
[button setAction:@selector(start:)];
```

- **Conceptually similar to function pointer**
- **Selectors include the name and all colons, for example:**

```
(void)setName:(NSString *)name age:(int)age;
```

- **Would have a selector:**

```
SEL sel = @selector(setName:age:);
```


Working with selectors

- **You can determine if an object responds to a given selector**

```
id obj;

SEL sel = @selector(start:);

if ([obj respondsToSelector:sel]) {
    [obj performSelector:sel withObject:self];
  //equivalent to [obj start:self];
  //For multiple arguments use … withObject:  withObject:
}
```

- **This sort of introspection and dynamic messaging underlies many Cocoa design patterns**

```
-(void)setTarget:(id)target;
-(void)setAction:(SEL)action;
```

More Info on Selectors

- **Selectors are unique identifiers that replace the name of methods when compiled**
- **Compiler writes each method name into a table and associates it with this unique id (the selector)**
- **The compiler assigns all method names a unique selector or SEL (the selector type)**
  - Every "method name" whether it is a part of your class or another class has an entry in that table with a unique selector value
- **More information at:**
  https://developer.apple.com/mac/library/documentation/Cocoa/Conceptual/ObjectiveC/Articles/ocSelectors.html

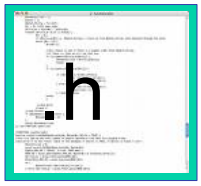
Custom Classes

Design Phase

- **Create a class**
  - Person
- **Determine the superclass**
  - NSObject (in this case)
- **What properties should it have?**
  - Name, age, whether they can vote
- **What actions can it perform?**
  - Cast a ballot

Defining a class

A public header and a private implementation



Header file

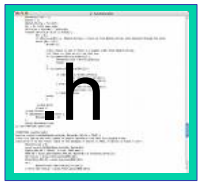
Implementation file

Class interface declared in header file

```
#import <Foundation/Foundation.h>
@interface Person : NSObject
{
    // instance variables
    NSString *name;
    int age;
}

// method declarations
- (NSString *)name;
- (void)setName:(NSString *)value;

- (int)age;
- (void)setAge:(int)age;
- (BOOL)canLegallyVote;
- (void)castBallot;

@end
```


Defining a class

A public header and a private implementation



Header file

Implementation file

Implementing custom class

- Implement setter/getter methods
- Implement action methods

Class Implementation

```
#import "Person.h“

@implementation Person

-(int)age {
  return age;
}

-(void)setAge:(int)value {
   age = value;
}
//... and other methods

@end
```

Calling your own methods

```
#import "Person.h“

@implementation Person

-(BOOL)canLegallyVote {
   return ([self age] >= 18);
}

-(void)castBallot {
    if ([self canLegallyVote]) {
       // do voting stuff
    } else {
       NSLog (@“I’m not allowed to vote!”);
    }
} @end
```

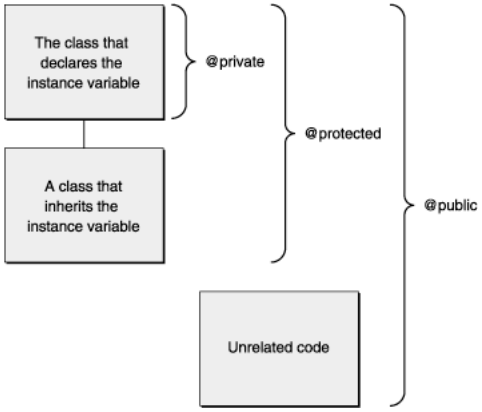

Superclass methods

- As we just saw, objects have an implicit variable named “self”
  - Like “this” in Java and C++
- Can also invoke superclass methods using “super”

```
-(void)doSomething {
   // Call superclass implementation first
   [super doSomething];

  // Then do our custom behavior
  int foo = bar;
  // ...
}
```

Public and Private Instance Variables

- By default all variables are protected



Instance Variable Protection

```
@interface Worker : NSObject
{
 char *name;  //actually protected

 @private
   int age;
   char *evaluation;

 @protected
   id job;
   float wage;

 @public
  id boss;

}
```

Objective C methods are all public (a way around this…)
http://iphonedevelopertips.com/objective-c/private-methods.html

Private Methods

- Private methods in Objective-C are declared in your .m file

```
@interface Worker ()

  - (void) myPrivateMethod1;
  - (int) anotherPrivateMethod:  (NSString *) myStringArgument

@end


@implementation Worker

 -(void) myPrivateMethod1 {
   //Do something here
  }

  -(int) anotherPrivateMethod: (NSString *) myStringArgument {
    return 0;
  }

  - (void)  somePublicMethod {

  }

@end
```


Object Lifecycle

Object Lifecycle

- Creating objects
- Memory management
- Destroying objects

Object Creation

- Two step process
  - allocate memory to store the object
  - initialize object state

+alloc

- Class method that knows how much memory is needed

-init

- Instance method to set initial values, perform other setup

Create = Allocate + Initialize

```
Person *student = nil;

student = [[Person alloc] init];
```

Or

```
Person *student = nil;
student = [Person alloc];
student = [student init];
```


Implementing your own -init method

```
#import "Person.h“

@implementation Person

-(id)init {
  // allow superclass to initialize its state first
   self = [super init];
  if (self != nil) {
            age = 0;
            name = @“Bob”;

     // do other initialization...
  }
  return self;
}

@end
```

Multiple init methods

- Classes may define multiple init methods

```
- (id)init;
- (id)initWithName:(NSString *)name;
- (id)initWithName:(NSString *)name age:(int)age;
```

- Less specific ones typically call more specific with default values
  - Designated Initializers

```
- (id)init { return [self initWithName:@"Bob"];
}
- (id)initWithName:(NSString *)name {
 return [self initWithName:name age:0];
}
```


Finishing Up With an Object

```
Person *person = nil;

person = [[Person alloc] init];

[person setName:@"Alan Cannistraro"];
[person setAge:29];
[person setWishfulThinking:YES];

[person castBallot];

// What do we do with person when we're done?
```

Two flavors of Memory Management

- **Automatic Reference Counting (ARC)**
  - Full support starting in iOS 5
- **Manual Reference Counting**
  - Original Objective C design
- **Choose one or the other**
  - Do not attempt to use both in the same .m file

Why learn both methods?

- **Many of the tutorials and examples on the web were created pre-ARC**
- **A solid understanding of manual reference counting makes ARC easier to understand**
- **Xcode can run into problems with migrating existing code to use ARC**

(Manual) Memory Management

	Allocation	Destruction
C	malloc	free
Objective-C	alloc	dealloc

- **Calls must be balanced**
  - Otherwise your program may leak or crash
- **However, you'll never call -dealloc directly**
  - One exception, we'll see in a bit...

(Manual) Reference Counting

- **Every object has a retain count**
  - Defined on NSObject
  - As long as retain count is > 0, object is alive and valid

- **+alloc and -copy create objects with retain count == 1**
- **-retain increments retain count**
- **-release decrements retain count**

- **When retain count reaches 0, object is destroyed**
- **-dealloc method invoked automatically**
  - One-way street, once you're in -dealloc there's no turning back

Balanced Calls

```
Person *person = nil;
person = [[Person alloc] init];

[person setName:@"John Smith"];
[person setAge:29];
[person setWishfulThinking:YES];

[person castBallot];

// When we're done with person, release it
[person release];  // person will be destroyed here
```


Reference counting in action

```
Person *person = [[Person alloc] init];
```

- Retain count begins at 1 with +alloc

```
[person retain];
```

- Retain count increases to 2 with –retain

```
[person release];
```

- Retain count decreases to 1 with –release

```
[person release];
```

- Retain count decreases to 0, -dealloc automatically called

Messaging deallocated objects

```
Person *person = [[Person alloc] init];
// ...
[person release]; // Object is deallocated

[person doSomething]; // Crash!
```


Messaging deallocated objects

```
Person *person = [[Person alloc] init];
// ...
[person release]; // Object is deallocated

person=nil;

[person doSomething]; // No effect
```

Implementing a -dealloc method

```
#import "Person.h"

@implementation Person

- (void)dealloc {
  // Do any cleanup that's necessary
  // ...

  // when we're done, call super to clean us up
  [super dealloc];
}
@end
```


Object Lifecycle Recap

- Objects begin with a retain count of 1
- Increase and decrease with -retain and –release
- When retain count reaches 0, object deallocated automatically
- You *never* call dealloc explicitly in your code
  - Exception is calling -[super dealloc]
  - You only deal with alloc, copy, retain, release

Object Ownership

```
#import <Foundation/Foundation.h>

@Interface Person : NSObject
{
  // instance variables
  NSString *name;    //Person class "owns" the name
  int age;
}

// method declarations
-(NSString *)name;
-(void)setName:(NSString *)value;

-(int)age;
-(void)setAge:(int)age;

-(BOOL)canLegallyVote;
-(void)castBallot;

@end
```


Object Ownership

```
#import "Person.h"
@implementation Person

- (NSString *)name {
  return name;
}

- (void)setName:(NSString *)newName {
   if (name != newName) {
      [name release];
      name = [newName retain];
      // name's retain count has been bumped up by 1
   }
}

@end
```

Object Ownership

```
#import "Person.h“
@implementation Person

- (NSString *)name {
  return name;
}

- (void)setName:(NSString *)newName {
   if (name != newName) {
      [name release];
      name = [newName copy];
      // name has a retain count of 1, we own it
   }
}

@end
```


Releasing Instance Variables

```
#import "Person.h“
@implementation Person

- (void)dealloc{
    //Do any cleanup that’s necessary
    [name release];

    // when we’re done, call super to clean us up
    [super dealloc];
}

@end
```

Autorelease

Returning a newly created object

```
-(NSString *)fullName {
  NSString *result;

  result = [[NSString alloc] initWithFormat:@"%@ %@",
    firstName, lastName];

  return result;
}
```

- Wrong: result is leaked!

Returning a newly created object

```
-(NSString *)fullName {
  NSString *result;

  result = [[NSString alloc] initWithFormat:@"%@ %@",
    firstName, lastName];

  [result release];
  return result;
}
```

- Wrong: result is released too early!
- Uncertain what method returns

Returning a newly created object

```
-(NSString *)fullName {
  NSString *result;

  result = [[NSString alloc] initWithFormat:@"%@ %@",
    firstName, lastName];

  [result autorelease];
  return result;
}
```

- Just right: result is released, but not right away!
- Caller gets valid object and could retain if needed

Autoreleasing Objects

- Calling -autorelease flags an object to be sent release at some point in the future
- Let's you fulfill your retain/release obligations while allowing an object some additional time to live
- Makes it much more convenient to manage memory
- Very useful in methods which return a newly created object

Method Names & Autorelease

- Methods whose names includes **alloc** or **copy** return a retained object that the caller needs to release

```
NSMutableString *string = [[NSMutableString alloc] init];

// We are responsible for calling -release or –autorelease
[string autorelease];
```

- All other methods return autoreleased objects

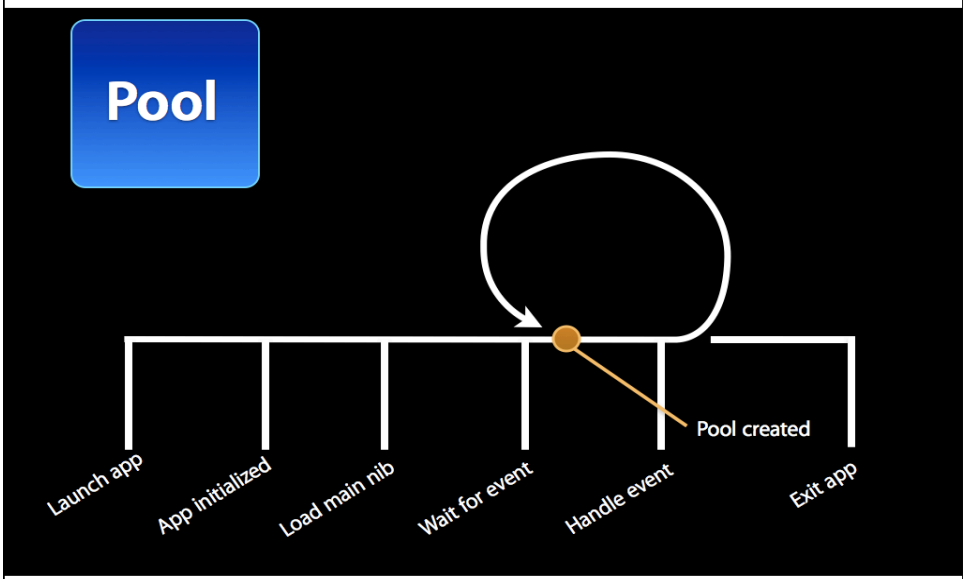
```
NSMutableString *string = [NSMutableString string];

// The method name doesn't indicate that we need to release it
// So don't- we're cool!
```

- This is a convention
  - follow it in methods you define

How does -autorelease work?

- **Object is added to current autorelease pool**
- **Autorelease pools track objects scheduled to be released**
  - When the pool itself is released, it sends -release to all its objects
- **UIKit automatically wraps a pool around every event dispatch**

Autorelease Pools (from cs193p slides)



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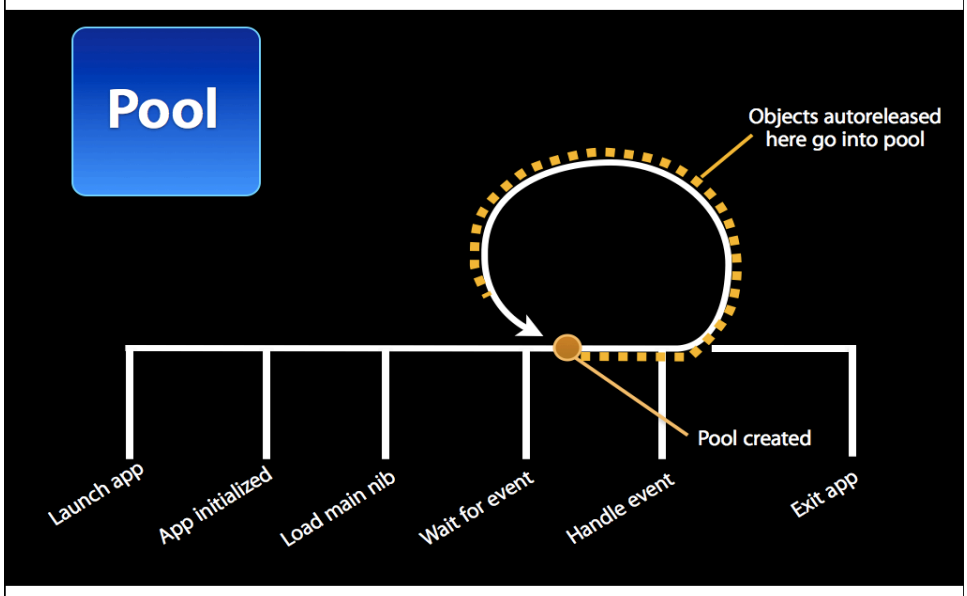

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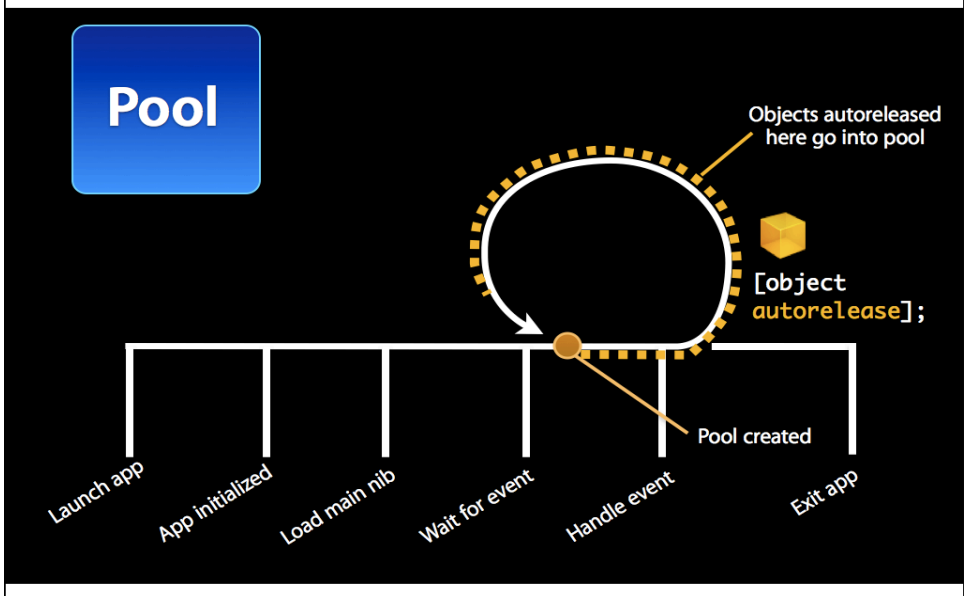

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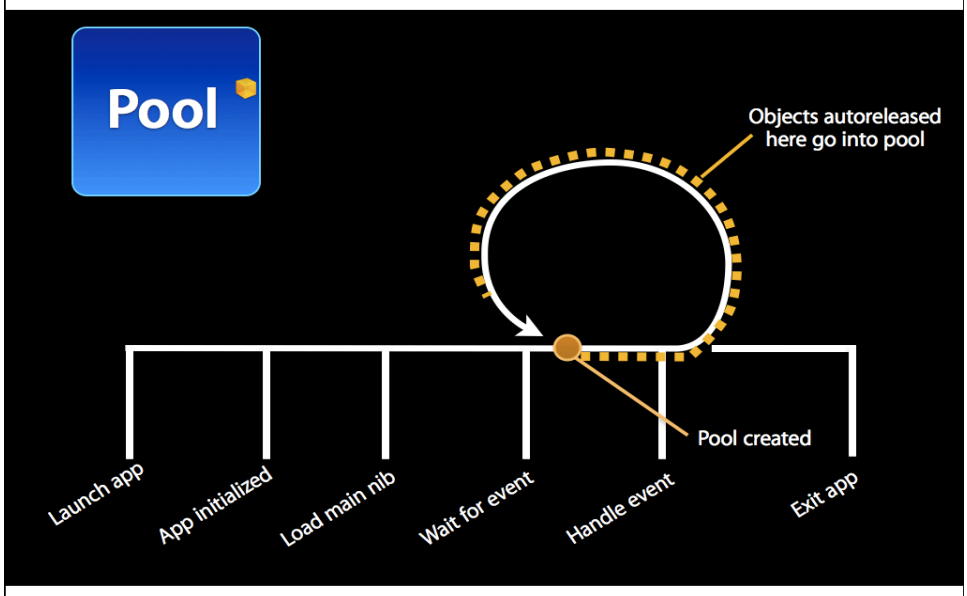

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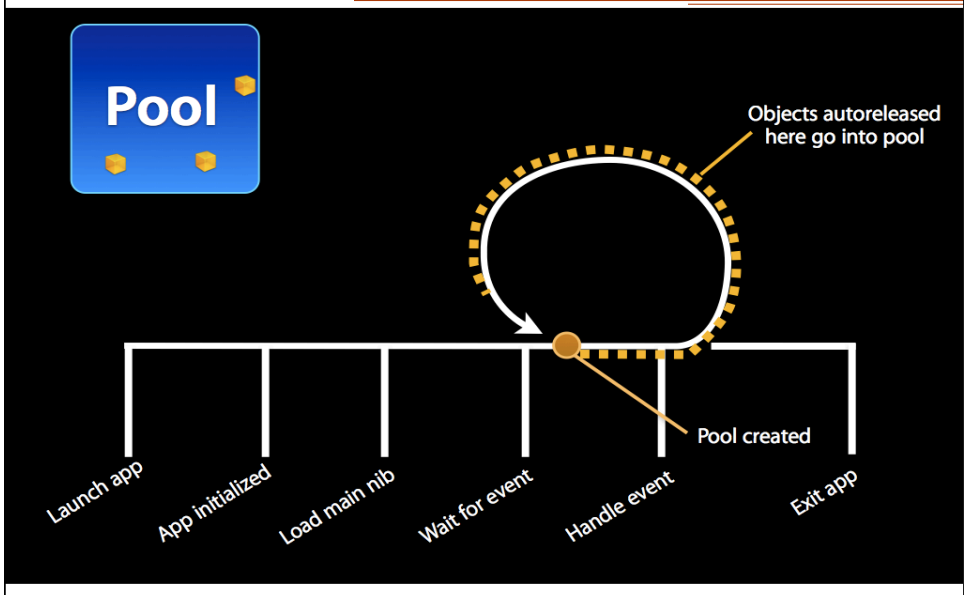

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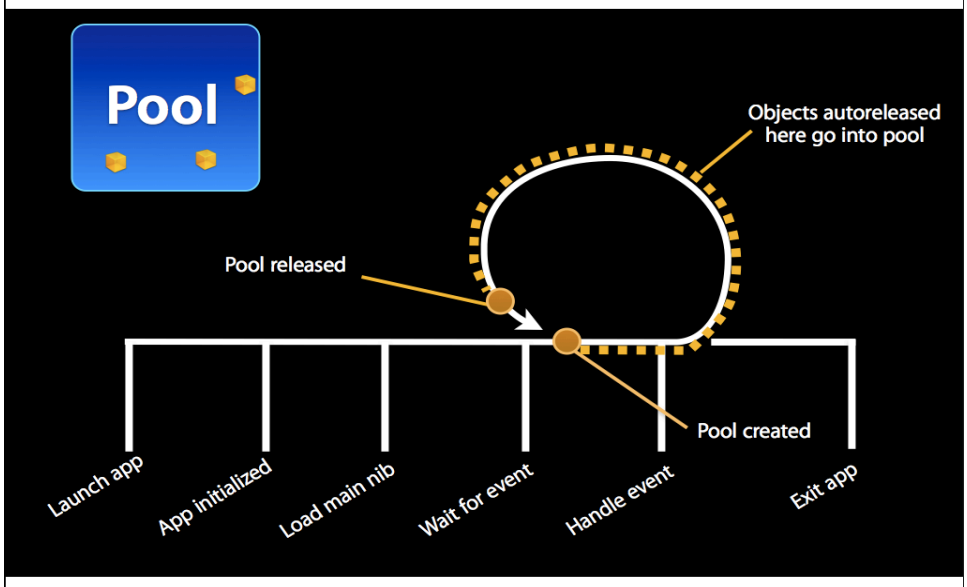

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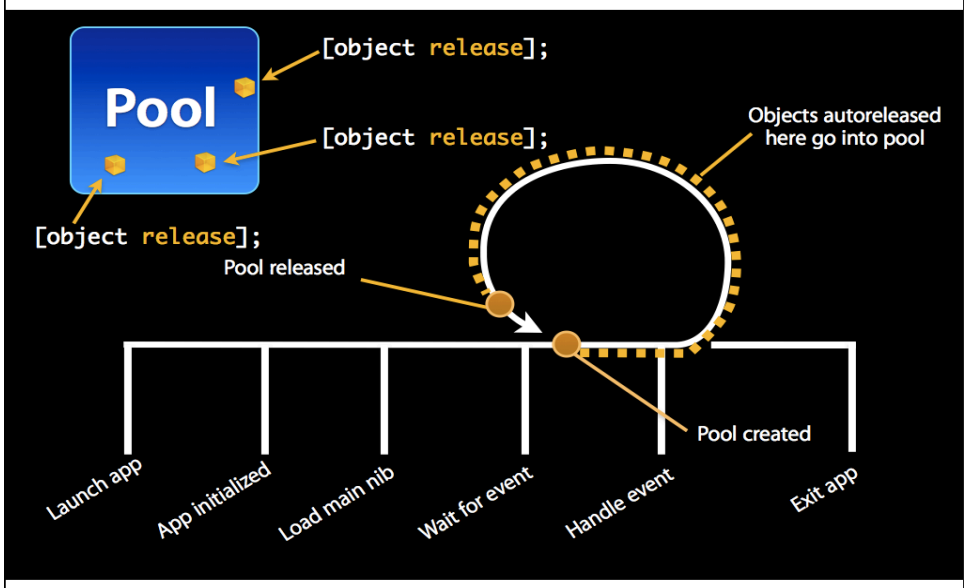

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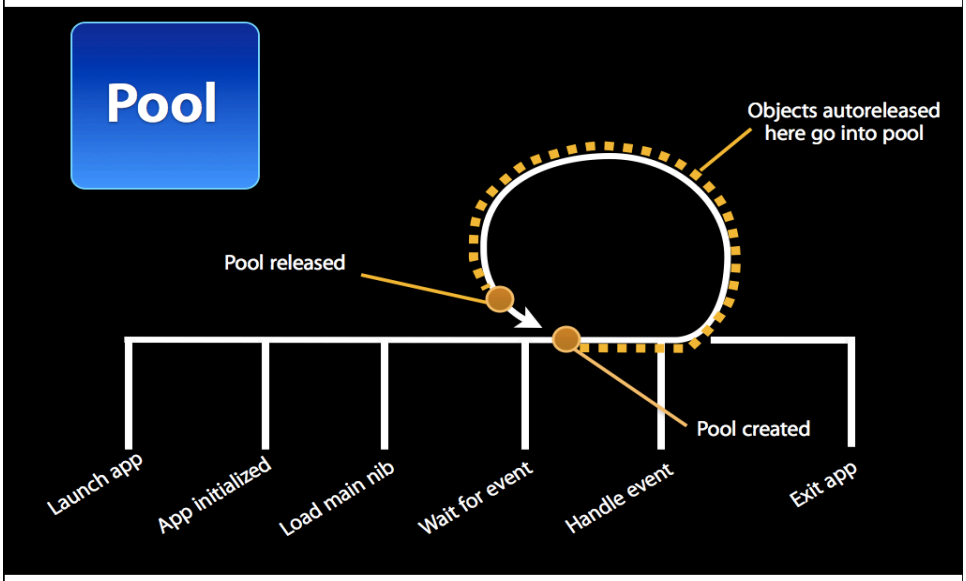

Hanging Onto an Autoreleased Object

- **Many methods return autoreleased objects**
  - Remember the naming conventions...
  - They're hanging out in the pool and will get released later
- **If you need to hold onto those objects you need to retain them**
  - Bumps up the retain count before the release happens

```
name = [NSMutableString string];

// We want to name to remain valid!
[name retain];
// ...
// Eventually, we'll release it (maybe in our -dealloc?)
[name release];
```

Side Note: Garbage Collection

- Autorelease is not garbage collection
- Objective-C on iPhone OS (iOS) does not have garbage collection