Announcements

–Final Project descriptions are due tonight

–Final Project Proposal slides are due tomorrow night

Final Project Point Distribution and Due Dates

- **The final project accounts for 30% of your final grade**
  - Final project score is out of 100 points
- **Final Project Group Description – 5 points**
  - Due on Monday November 5th by 11:59 PM
- **Project Proposal Presentation – 15 points**
  - Submit as PPT, Keynote, or Google slides
  - Due on Tuesday November 6th by 11:59 PM
- **Project Update – 10 points**
  - Provide a brief description of what has been accomplished in the email
  - Submit code to demonstrate the accomplishments
  - Submit either a 30 second recording or multiple screenshots (5 max) of your app
  - Due on Sunday November 25th by 11:59 PM
- **Final Project Code - 70 points**
  - Due on Monday December 3rd by 11:40 AM
- **Submit all portions of the final project to cse438ta@gmail.com**
- **Late submissions will result in a 0 for that portion of the final project**
- **Final Project groups consist of 4 - 5 people**

Today's Topics

- **Final Project App Idea**
- **Objective-C Language**

Guest Presentation

- **Amy Mueller**
  - Nurse Practitioner with the Adult Congenital Cardiology Team at Children's Hospital
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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

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

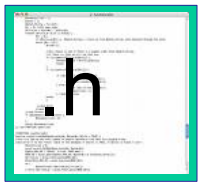
Custom Classes

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;
}

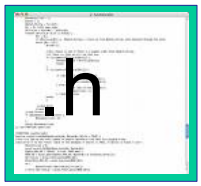
// method declarations
- (NSString *)name;
- (void)setName:(NSString *)value;

- (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

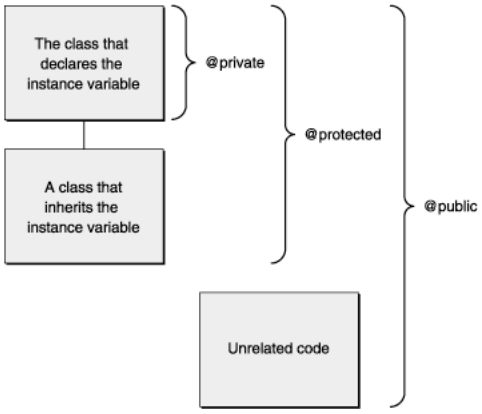
- As we just saw, objects have an implicit variable named “self”
  - Like “this” in Java and C++
- Can also invoke superclass methods using “super”

```
-(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];

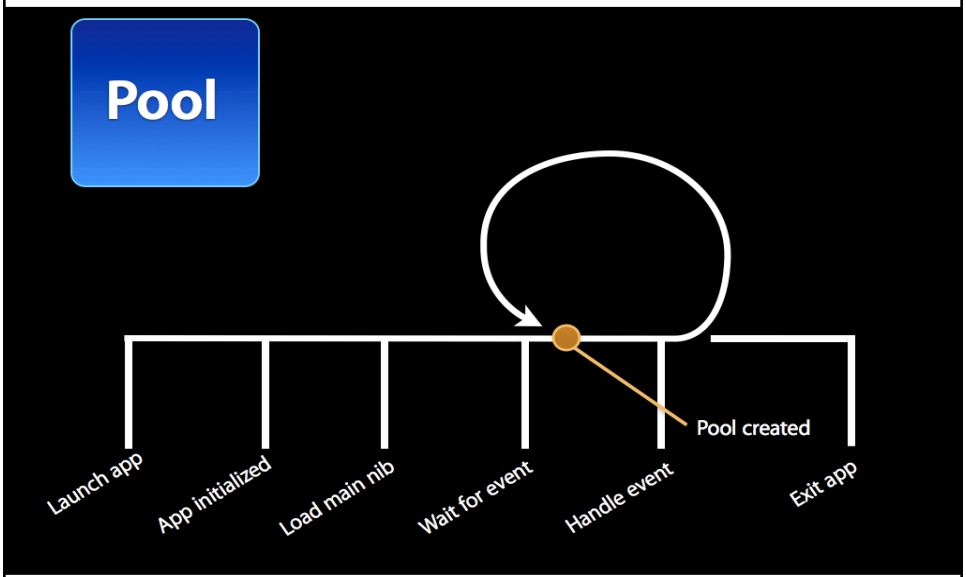
// The method name doesn't indicate that we need to release it
// So don't- we're cool!
```

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

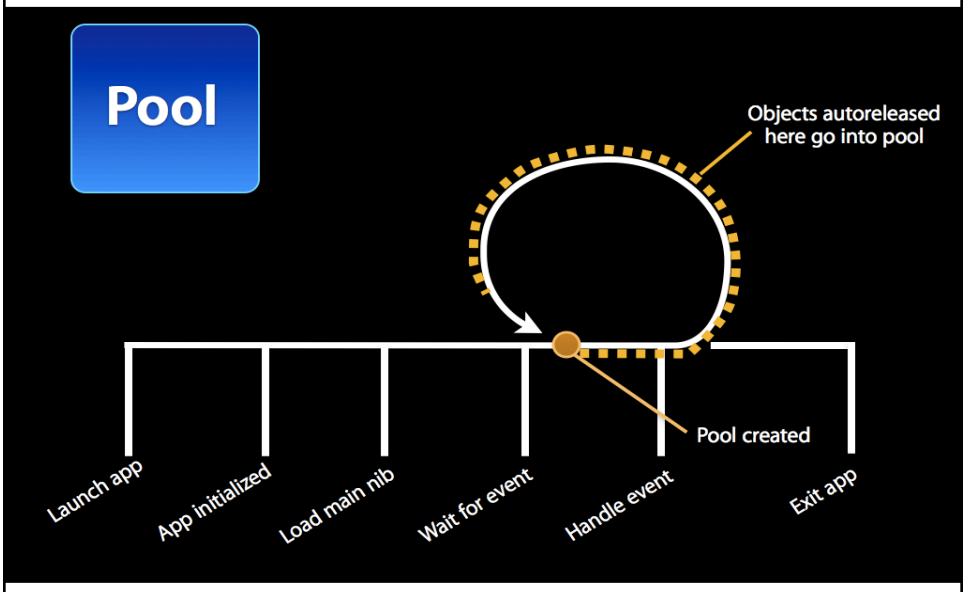
How does -autorelease work?

- **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)



Autorelease Pools (from cs193p slides)



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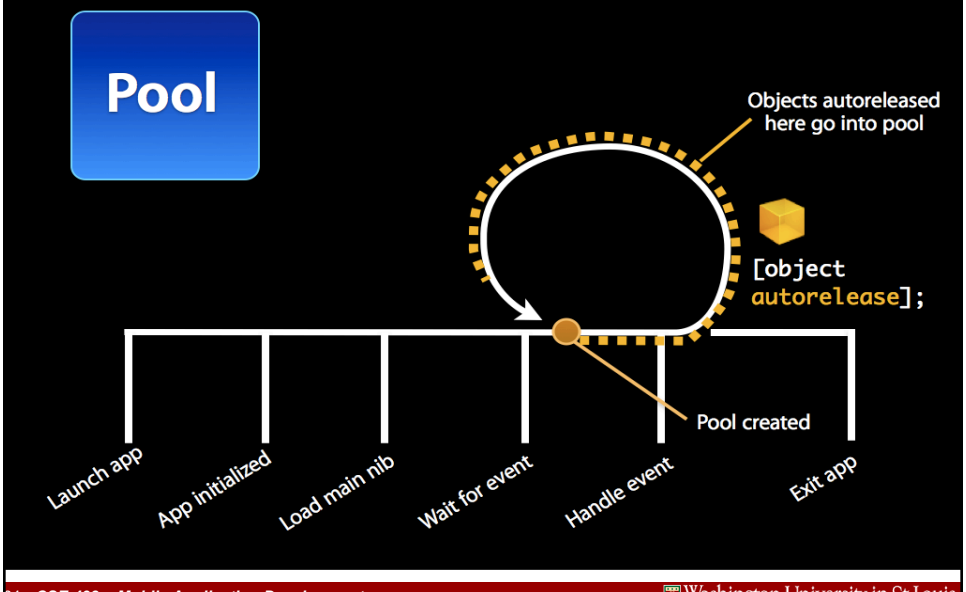

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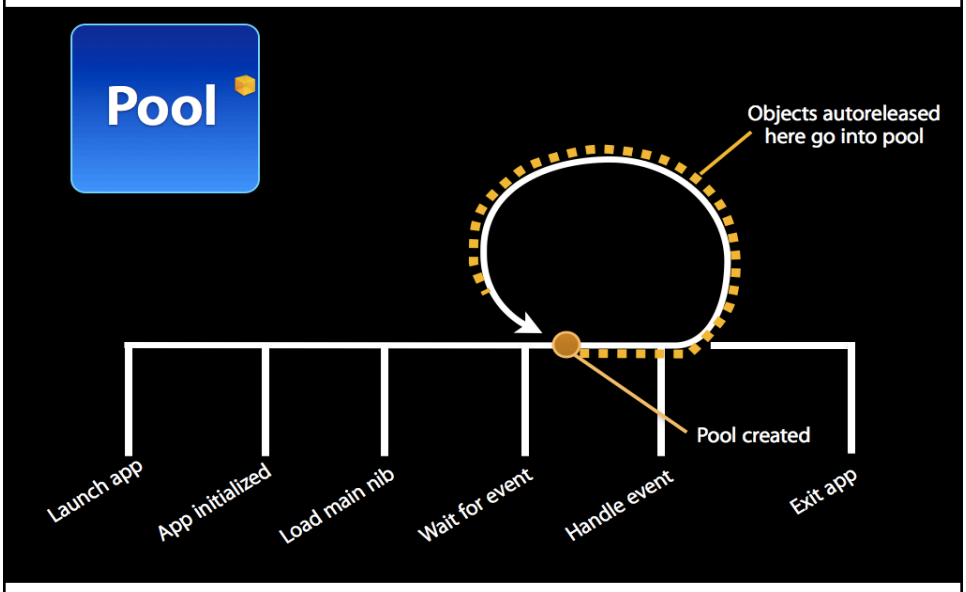

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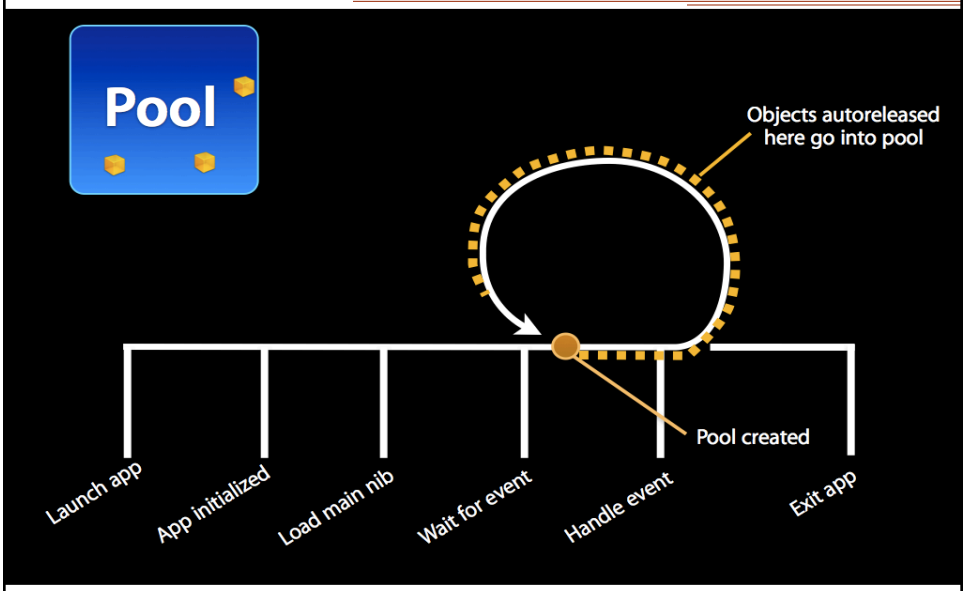

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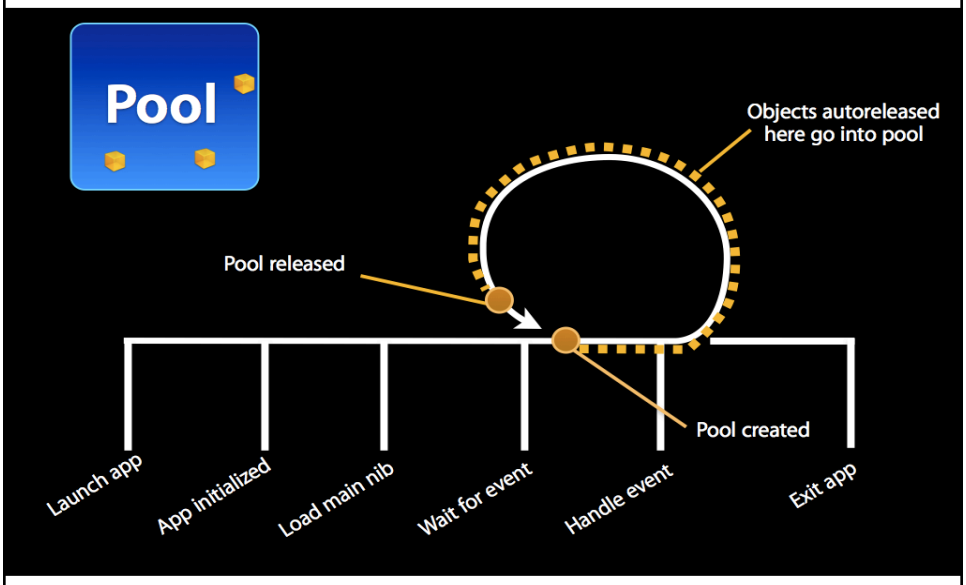

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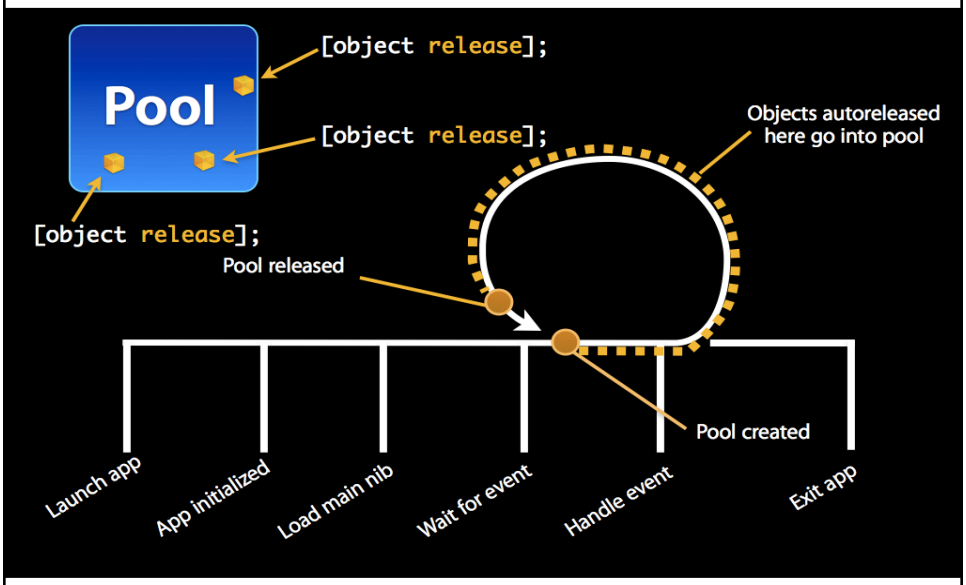

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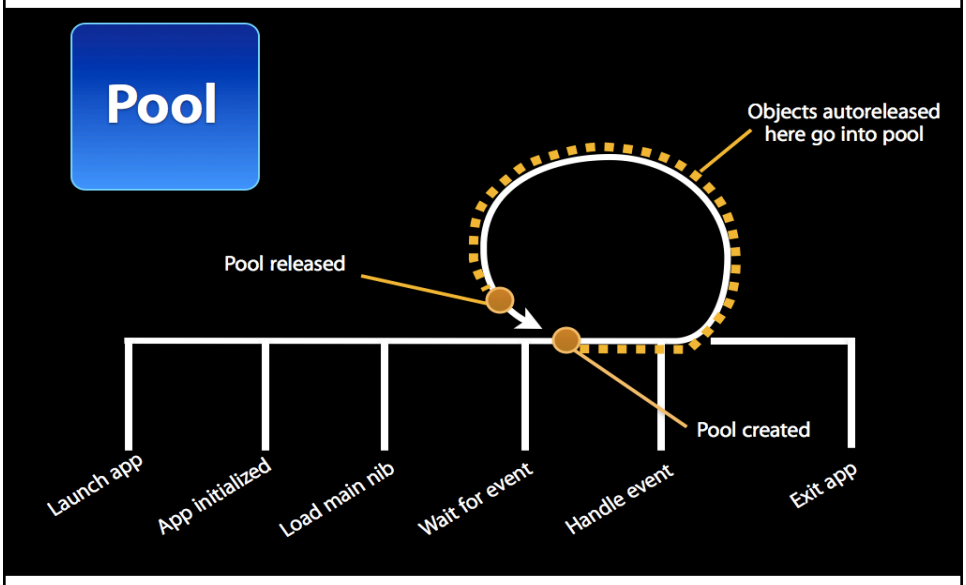


Hanging Onto an Autoreleased Object

- **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

Automatic Reference Counting (ARC)

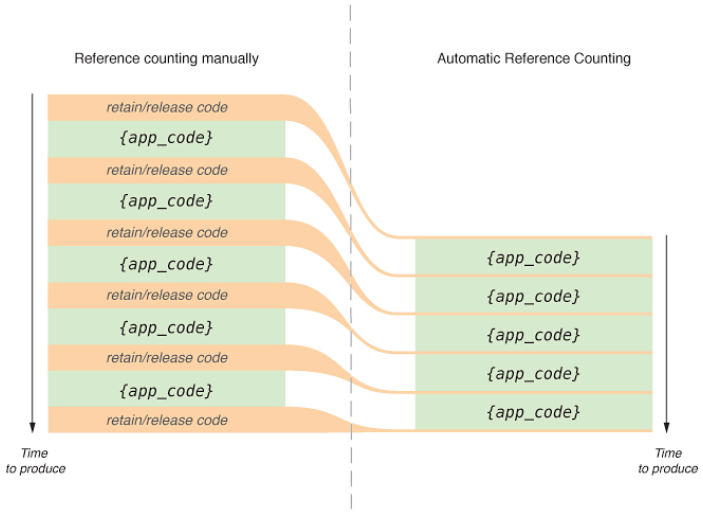
Automatic Reference Counting (ARC)

- **The new and "improved" way to manage memory**
  - All objects are either strong or weak
- **Strong**
  - Keep me around until I no longer need this memory
- **Weak**
  - Keep me around as long as some other object needs this memory

Automatic Reference Counting

- **By default all objects allocated when using ARC are strong**
  - NSNumber *myNumber = [NSNumber alloc] init];
- **Weak references are often used when pointing to objects on a storyboard**
  - UIButton, UILabel, UIImage
    - These objects are already instantiated when the storyboard loads
    - We just want a pointer to them while they are alive

Automatic Retain/Release



Properties

- **Provide access to object attributes**
- **Shortcut to implementing getter/setter methods**
- **Also allow you to specify:**
  - read-only versus read-write access
  - memory management policy

Defining Properties

```
#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 Properties

```
#import<Foundation/Foundation.h>
@interface Person : NSObject
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   NSString *name;
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// method declarations
-(NSString *)name;
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-(void)setAge:(int)age;
-(BOOL)canLegallyVote;

-(void)castBallot;
@end
```

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// method declarations
-(NSString *)name;
-(void)setName:(NSString *)value;
-(int)age;
-(void)setAge:(int)age;
-(BOOL)canLegallyVote;

-(void)castBallot;
@end
```


Defining Properties

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

// property declarations
@property int age;
@property (copy) NSString  *name;
@property (readonly) BOOL canLegallyVote;

-(void)castBallot;
@end
```

Synthesizing Properties

```
@implementation Person

-(int)age {
 return age;
}

-(void)setAge:(int)value {
  age = value;
}

-(NSString *)name {
  return name;
}

-(void)setName:(NSString *)value {
   if (value != name) {
      [value release];
      name = [value copy];
   }

- (BOOL)canLegallyVote { …
```


Synthesizing Properties

```
@implementation Person

-(int)age {
 return age;
}

-(void)setAge:(int)value {
  age = value;
}

-(NSString *)name {
  return name;
}

-(void)setName:(NSString *)value {
   if (value != name) {
      [value release];
      name = [value copy];
   }

- (BOOL)canLegallyVote { …
```

Synthesizing Properties

```
@implementation Person

-(int)age {
  return age;
 }

-(void)setAge:(int)value {
   age = value;
 }

-(NSString *)name {
   return name;
 }

-(void)setName:(NSString *)value {
    if (value != name) {
        [value release];
        name = [value copy];
    }

- (BOOL)canLegallyVote { ...
```


Synthesizing Properties

```
@implementation Person

@synthesize age;
@synthesize name;
-    (BOOL)canLegallyVote {
   return (age > 17);
}

@end
```

iOS Property Attributes

- Use strong and weak instead of retain and assign

```
@property (retain) NSString *name; // retain called
@property (strong) NSString *name;// new way


@property (assign) NSString *name; // pointer assignment
@property (weak) NSString *name; //new way
```


Property Names vs. Instance Variables

- Property name can be different than instance variable

```
@interface Person : NSObject {
  int numberOfYearsOld;
}

@property int age;

@end


@implementation Person

@synthesize age = numberOfYearsOld;

@end
```

Properties

- Mix and match synthesized and implemented properties

```
@implementation Person

@synthesize age;
@synthesize name;

(void)setAge:(int)value {
    age = value;
}
@end
```

- Setter method explicitly implemented
- Getter method still synthesized

Properties In Practice

- Newer APIs use @property
- Older APIs use getter/setter methods
- Properties used heavily throughout UIKit APIs
  - Not so much with Foundation APIs
- You can use either approach
  - Properties mean writing less code, but "magic" can sometimes be non-obvious

Further Reading

- **Objective-C 2.0 Programming Language**
  - "Defining a Class"
  - "Declared Properties"
- **Memory Management Programming Guide for Cocoa**