CS193P - Lecture 3

iPhone Application Development

Custom Classes
Object Lifecycle
Autorelease
Properties

Announcements

- Assignments 1A and 1B **due Wednesday 1/13 at 11:59 PM**
  - Enrolled Stanford students can email cs193p@cs.stanford.edu with any questions
  - Submit early! Instructions on the website...
    - **Delete the "build" directory manually, Xcode won't do it**

Announcements

- Assignments 2A and 2B **due Wednesday 1/20 at 11:59 PM**
  - 2A: Continuation of Foundation tool
    - Add custom class
    - Basic memory management
  - 2B: Beginning of first iPhone application
    - Topics to be covered on Thursday, 1/14
    - Assignment contains extensive walkthrough

Enrolled students & iTunes U

- Lectures have begun showing up on iTunes U
- Lead time is longer than last year
- **Come to class!!**
  - Lectures may not post in time for assignments

Office Hours

- Paul's office hours: Thursday 2-4, Gates B26B
- David's office hours: Mondays 4-6pm: Gates 360

Today's Topics

- Questions from Assignment 1A or 1B?
- Creating Custom Classes
- Object Lifecycle
- Autorelease
- Objective-C Properties

Custom Classes

Design Phase

Design Phase

- Create a class
  - Person

Design Phase

- Create a class
  - Person
- Determine the superclass
  - NSObject (in this case)

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- Create a class
  - Person
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  - NSObject (in this case)
- What properties should it have?
  - Name, age, whether they can vote

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

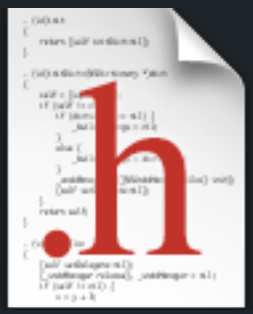
A public header and a private implementation

Header File

Implementation File

Defining a class

A public header and a private implementation



Header File

Implementation File

Class interface declared in header file

Class interface declared in header file

```
@interface Person


@end
```

Class interface declared in header file

```
@interface Person  : NSObject



@end
```

Class interface declared in header file

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

@interface Person  : NSObject




@end
```

Class interface declared in header file

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

@interface Person  : NSObject
{



}









@end
```

Class interface declared in header file

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

@interface Person  : NSObject
{
    // instance variables
    NSString *name;
    int age;
}

@end
```

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;

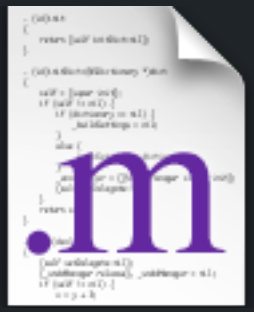
- (BOOL)canLegallyVote;
- (void)castBallot;

@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

Class Implementation

```
#import "Person.h"
```

Class Implementation

```
#import "Person.h"

@implementation Person









@end
```

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

Calling your own methods

```
#import "Person.h"

@implementation Person

- (BOOL)canLegallyVote {

}

- (void)castBallot {




}

@end
```

Calling your own methods

```
#import "Person.h"

@implementation Person

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

- (void)castBallot {




}

@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”

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;
  // ...
}
```

Object Lifecycle

Object Lifecycle

- Creating objects
- Memory management
- Destroying objects

Object Creation

Object Creation

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

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  - initialize object state

```
+ alloc
```

  - Class method that knows how much memory is needed

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

Create = Allocate + Initialize

```
Person *person = nil;
```

Create = Allocate + Initialize

```
Person *person = nil;

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

Implementing your own -init method

```
#import "Person.h"

@implementation Person

@end
```

Implementing your own -init method

```
#import "Person.h"

@implementation Person

- (id)init {









}

@end
```

Implementing your own -init method

```
#import "Person.h"

@implementation Person

- (id)init {
  // allow superclass to initialize its state first
  if (self = [super init]) {




  }

  return self;
}

@end
```

Implementing your own -init method

```
#import "Person.h"

@implementation Person

- (id)init {
  // allow superclass to initialize its state first
  if (self = [super init]) {
       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;
```

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

```
- (id)init {
    return [self initWithName:@“No Name”];
}

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

Finishing Up With an Object

```
Person *person = nil;

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

Finishing Up With an Object

```
Person *person = nil;

person = [[Person alloc] init];

[person setName:@“Jimmy Jones”];
[person setAge:32];

[person castBallot];
[person doSomethingElse];
```

Finishing Up With an Object

```
Person *person = nil;

person = [[Person alloc] init];

[person setName:@“Jimmy Jones”];
[person setAge:32];

[person castBallot];
[person doSomethingElse];

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

Memory Management

	Allocation	Destruction

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C	`malloc`	`free`

Memory Management

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C	`malloc`	`free`
Objective-C	`alloc`	`dealloc`

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- Calls must be balanced
  - Otherwise your program may leak or crash

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...

Reference Counting

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

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- `+alloc` and `-copy` create objects with retain count == 1
- `-retain` increments retain count

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- `-release` decrements retain count

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];
```

Balanced Calls

```
Person *person = nil;

person = [[Person alloc] init];

[person setName:@“Jimmy Jones”];
[person setAge:32];

[person castBallot];
[person doSomethingElse];
```

Balanced Calls

```
Person *person = nil;

person = [[Person alloc] init];

[person setName:@“Jimmy Jones”];
[person setAge:32];

[person castBallot];
[person doSomethingElse];

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

Reference counting in action

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

Reference counting in action

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

Retain count begins at 1 with +alloc

Reference counting in action

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Person *person = [[Person alloc] init];
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Retain count begins at 1 with +alloc

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[person retain];
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Retain count increases to 2 with -retain

Reference counting in action

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Person *person = [[Person alloc] init];
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Retain count begins at 1 with +alloc

```
[person retain];
```

Retain count increases to 2 with -retain

```
[person release];
```

Reference counting in action

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

Retain count begins at 1 with +alloc

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[person retain];
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Retain count increases to 2 with -retain

```
[person release];
```

Retain count decreases to 1 with -release

Reference counting in action

```
Person *person = [[Person alloc] init];
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Retain count begins at 1 with +alloc

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[person retain];
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Retain count increases to 2 with -retain

```
[person release];
```

Retain count decreases to 1 with -release

```
[person release];
```

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

Messaging deallocated objects

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

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
```

Messaging deallocated objects

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

person = nil;
```

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









@end
```

Implementing a -dealloc method

```
#import "Person.h"

@implementation Person

- (void)dealloc {




}

@end
```

Implementing a -dealloc method

```
#import "Person.h"

@implementation Person

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



}

@end
```

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









@end
```

Object Ownership

```
#import "Person.h"

@implementation Person

- (NSString *)name {
    return name;
}
- (void)setName:(NSString *)newName {




}

@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 {




}

@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 retain count of 1, we own it
    }
}

@end
```

Releasing Instance Variables

```
#import "Person.h"

@implementation Person




@end
```

Releasing Instance Variables

```
#import "Person.h"

@implementation Person

- (void)dealloc {




}

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



}

@end
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Releasing Instance Variables

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#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;
}
```

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;
}
```

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**!
Method returns bogus value

Returning a newly created object

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

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


    return result;
}
```

Returning a newly created object

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

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

    [result autorelease];

    return result;
}
```

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

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

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```
NSMutableString *string = [[NSMutableString alloc] init];
// We are responsible for calling -release or -autorelease
[string autorelease];
```

Method Names & Autorelease

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

```
NSMutableString *string = [[NSMutableString alloc] init];
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- All other methods return autoreleased objects

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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!
```

Method Names & Autorelease

- Methods whose names includes **alloc, copy, or new** 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?

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- Object is added to **current autorelease pool**

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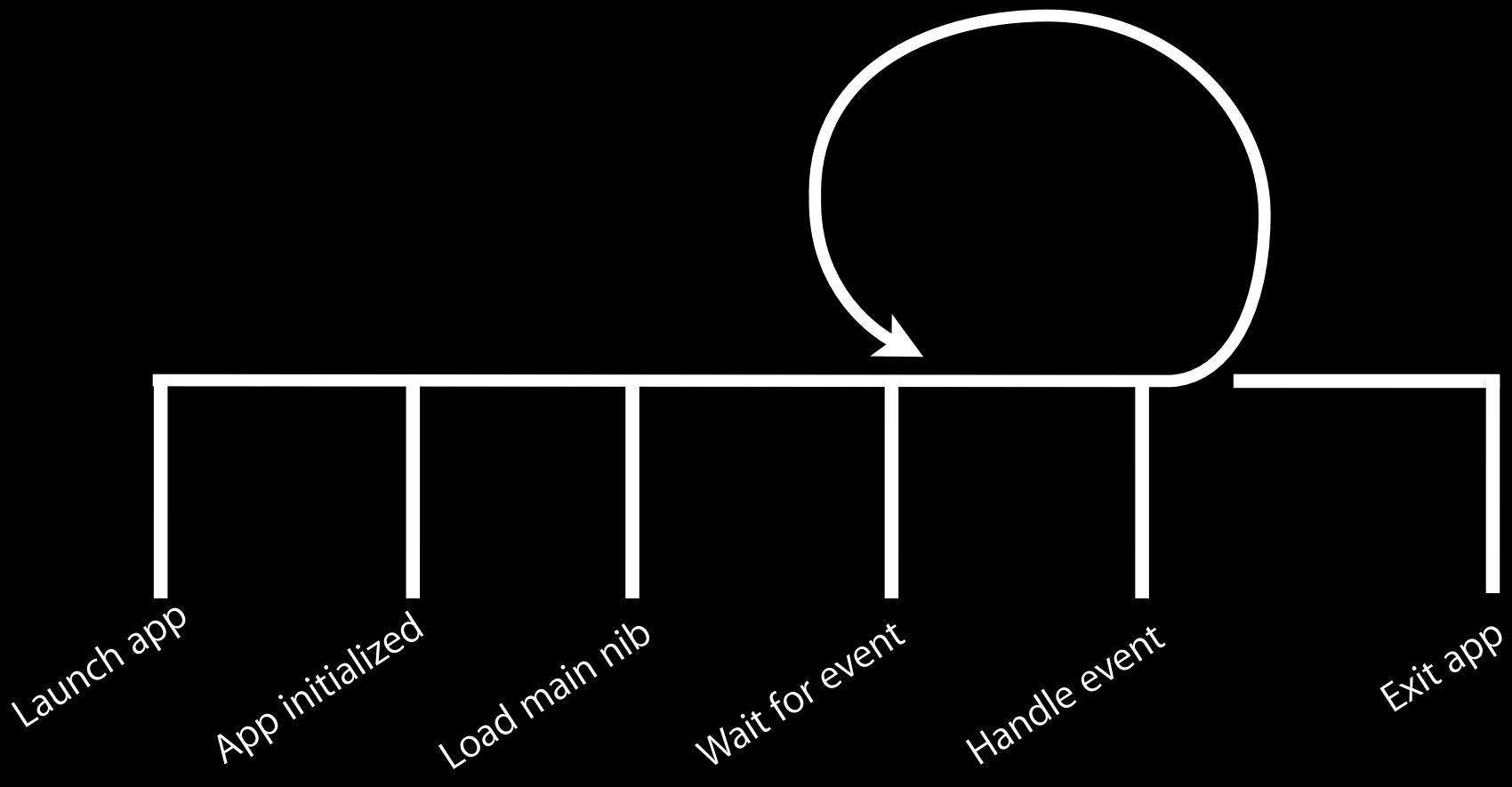
- Object is added to **current autorelease pool**
- Autorelease pools track objects scheduled to be released
  - When the pool itself is released, it sends -release to all its objects

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 (in pictures)



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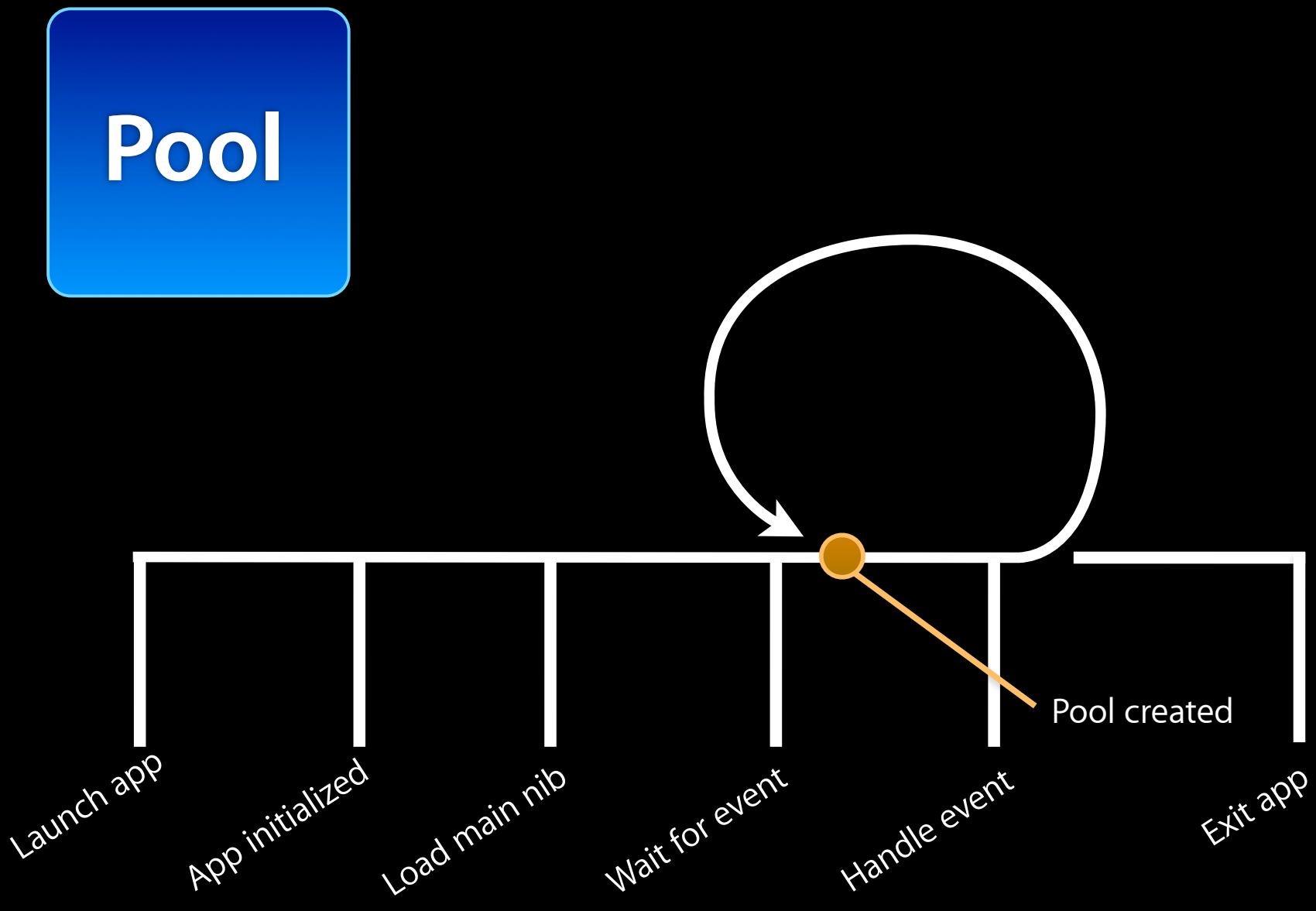

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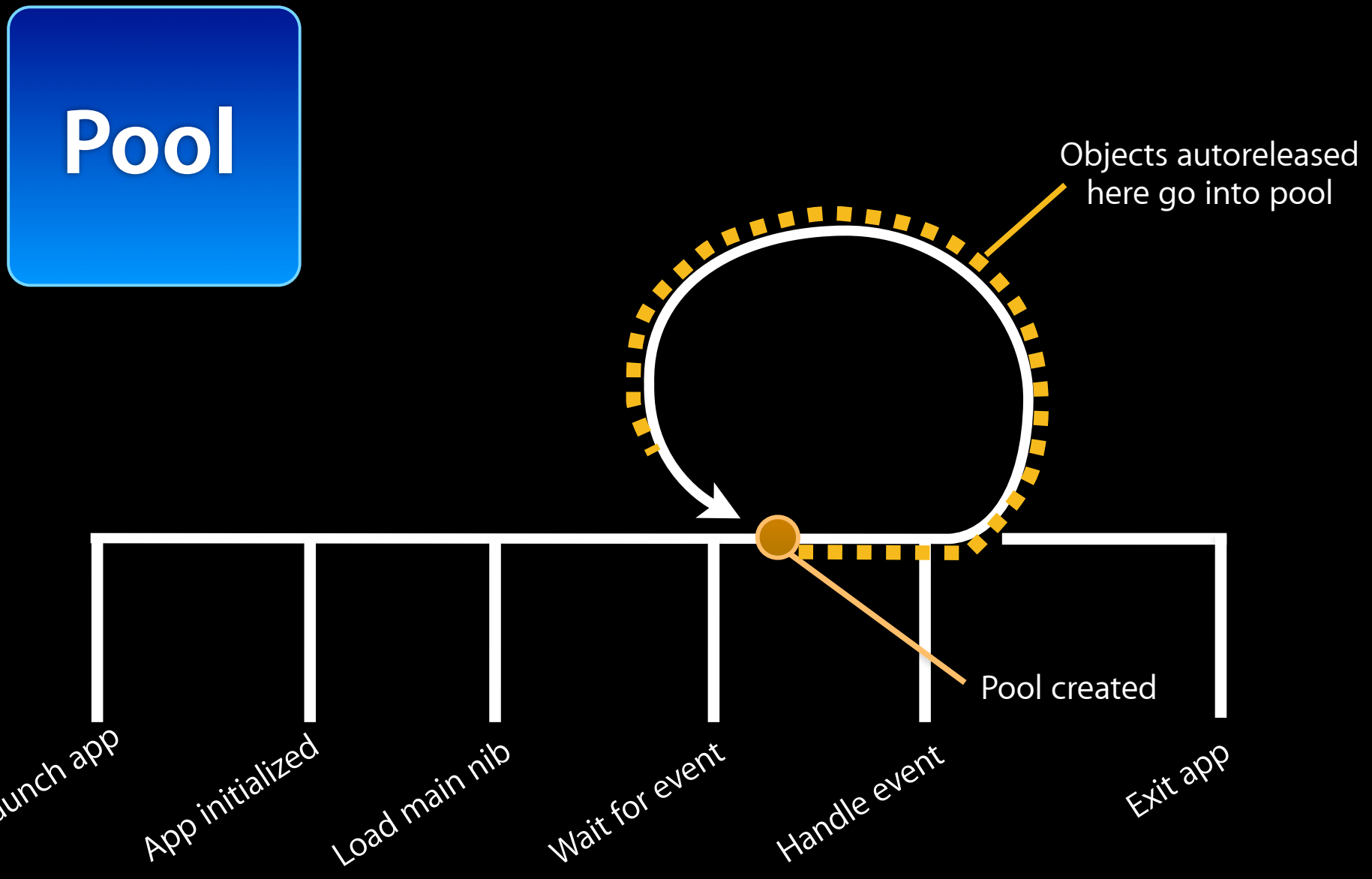

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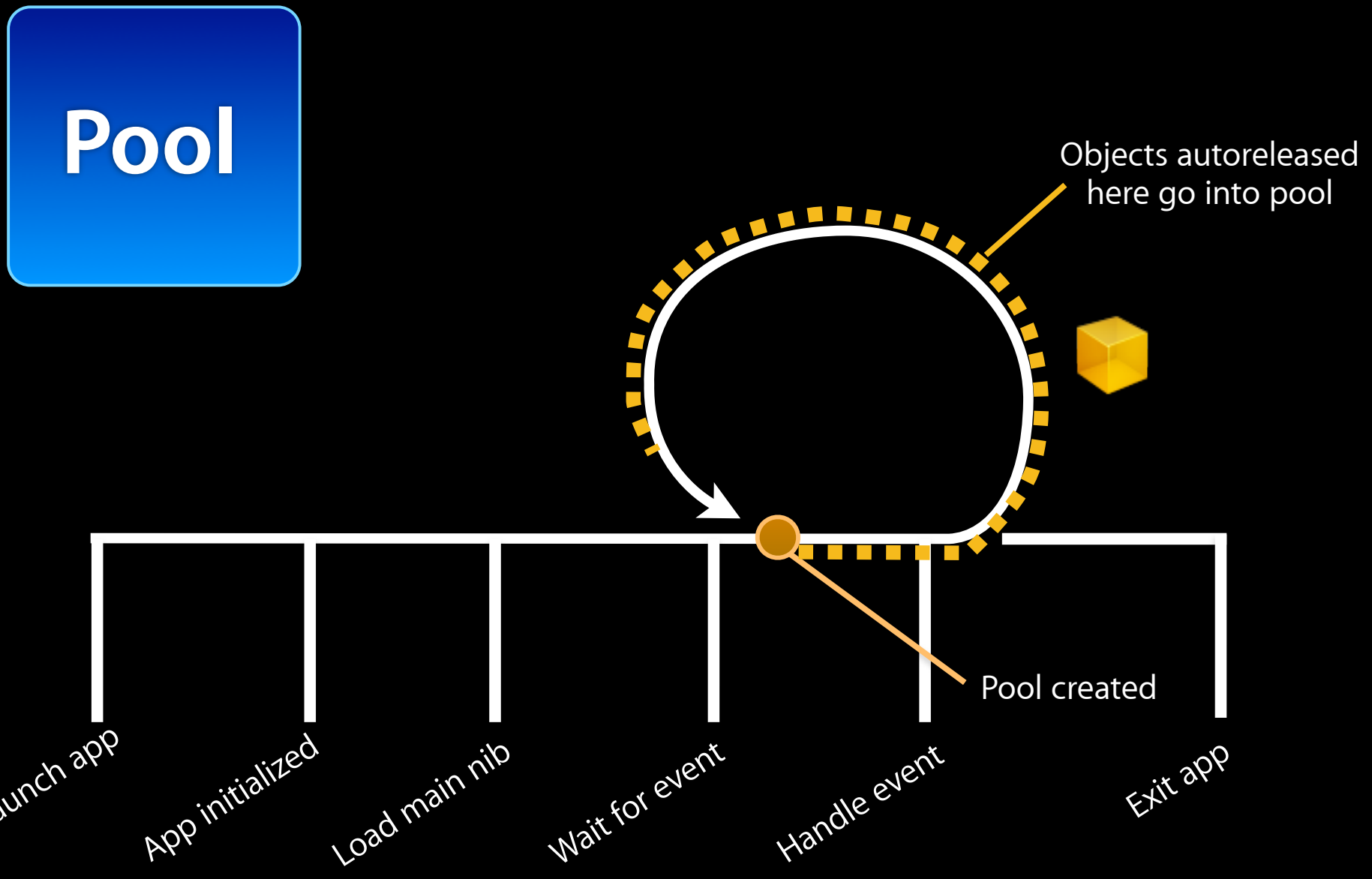

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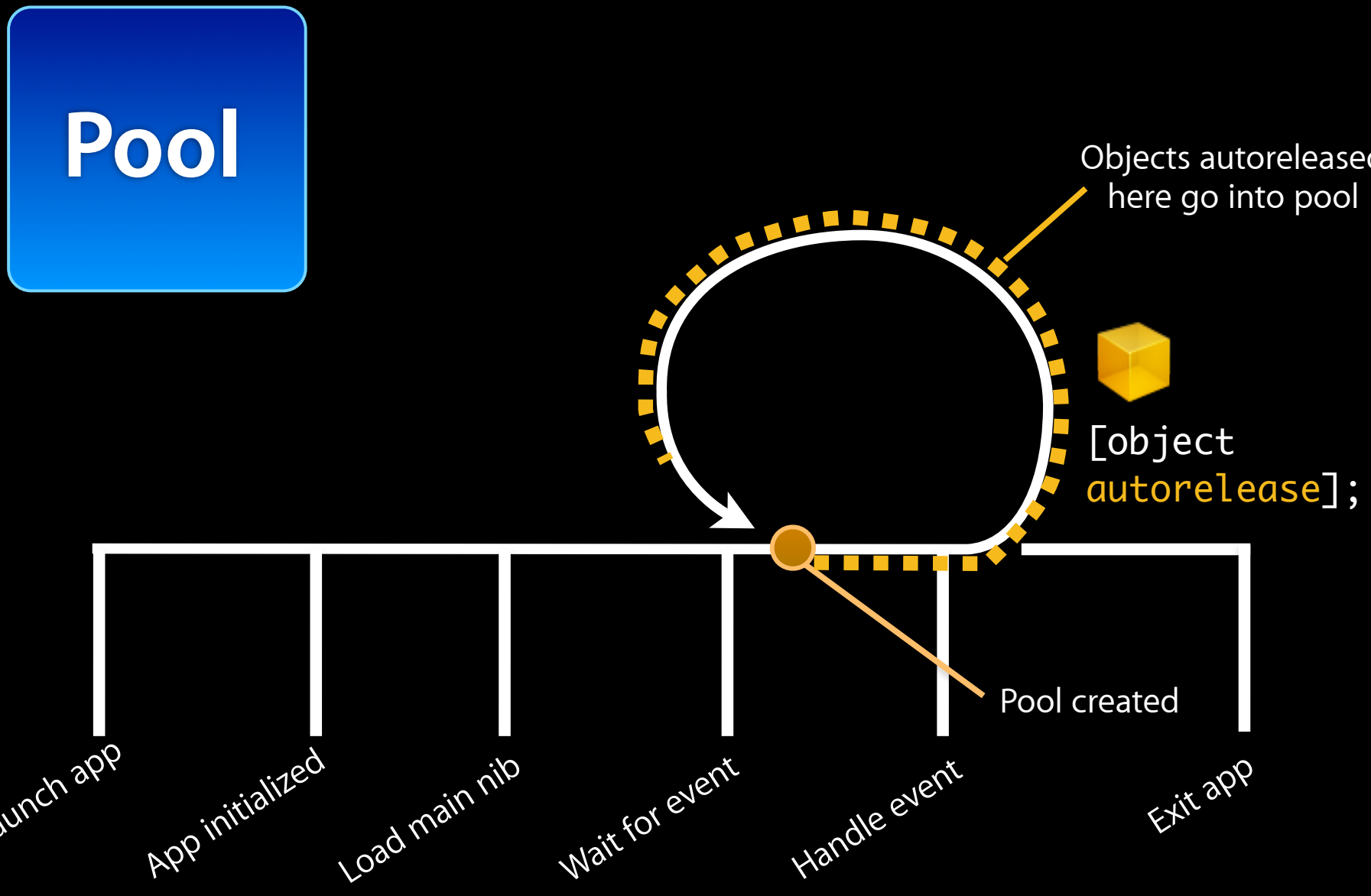

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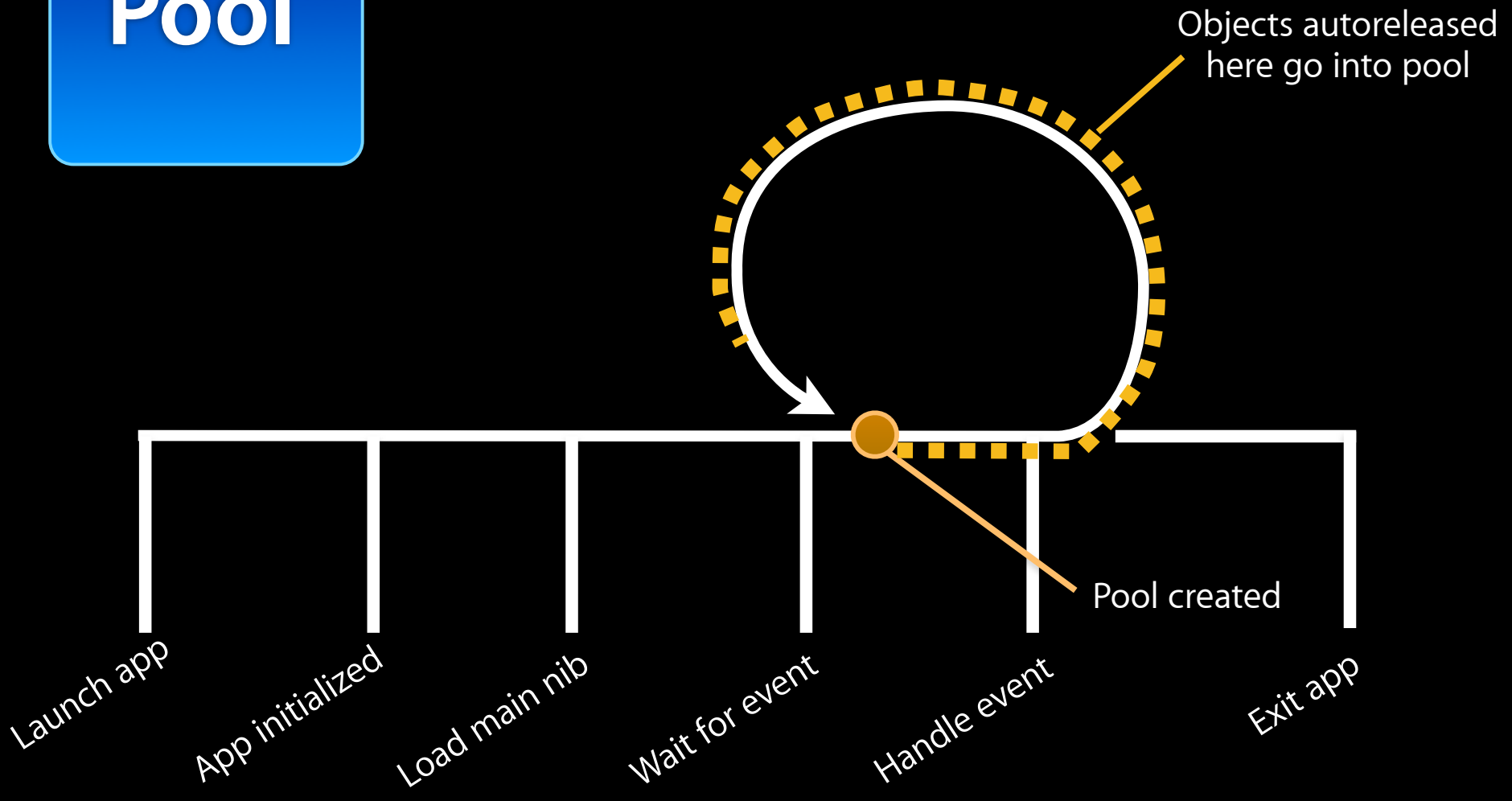

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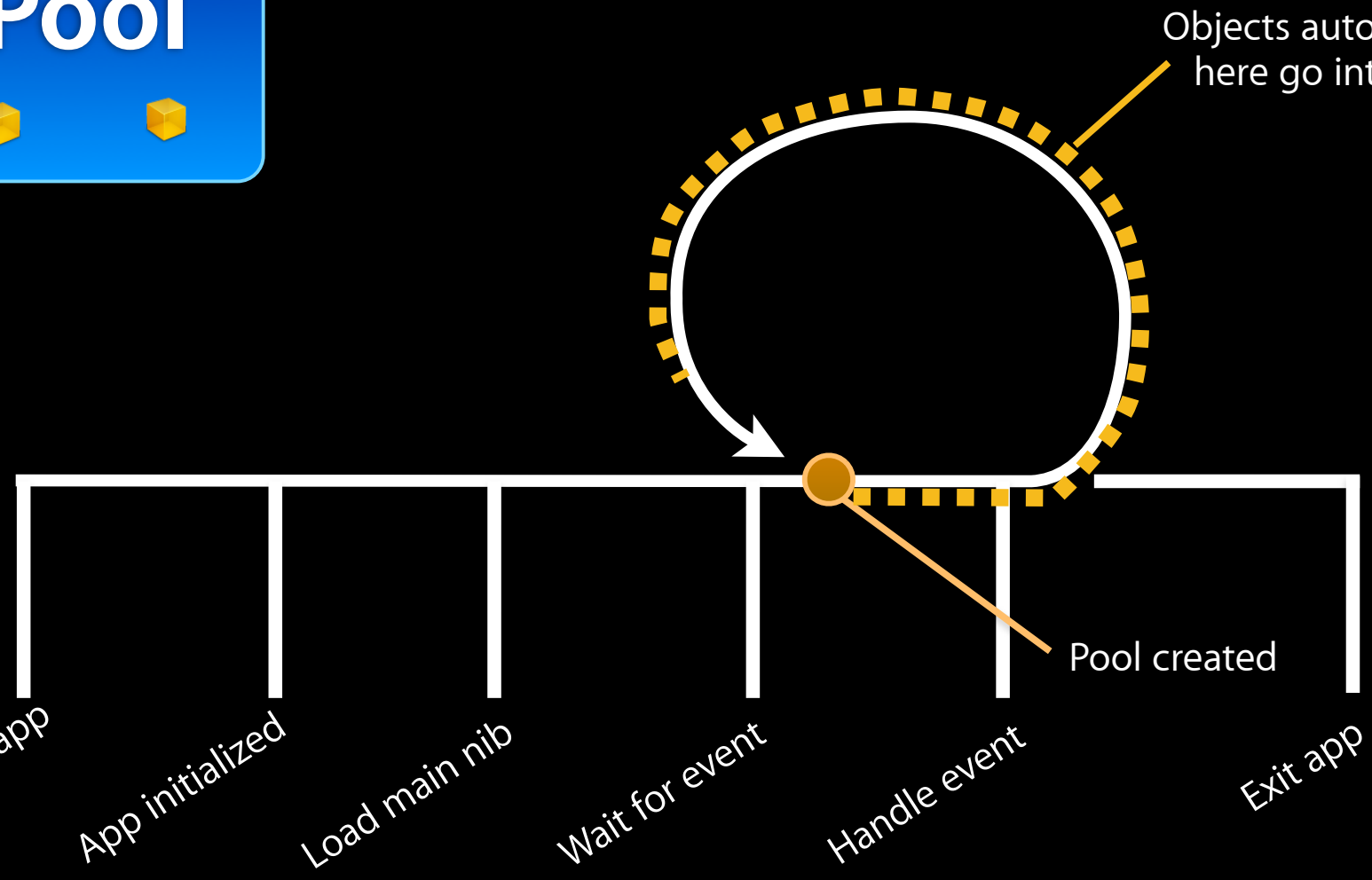

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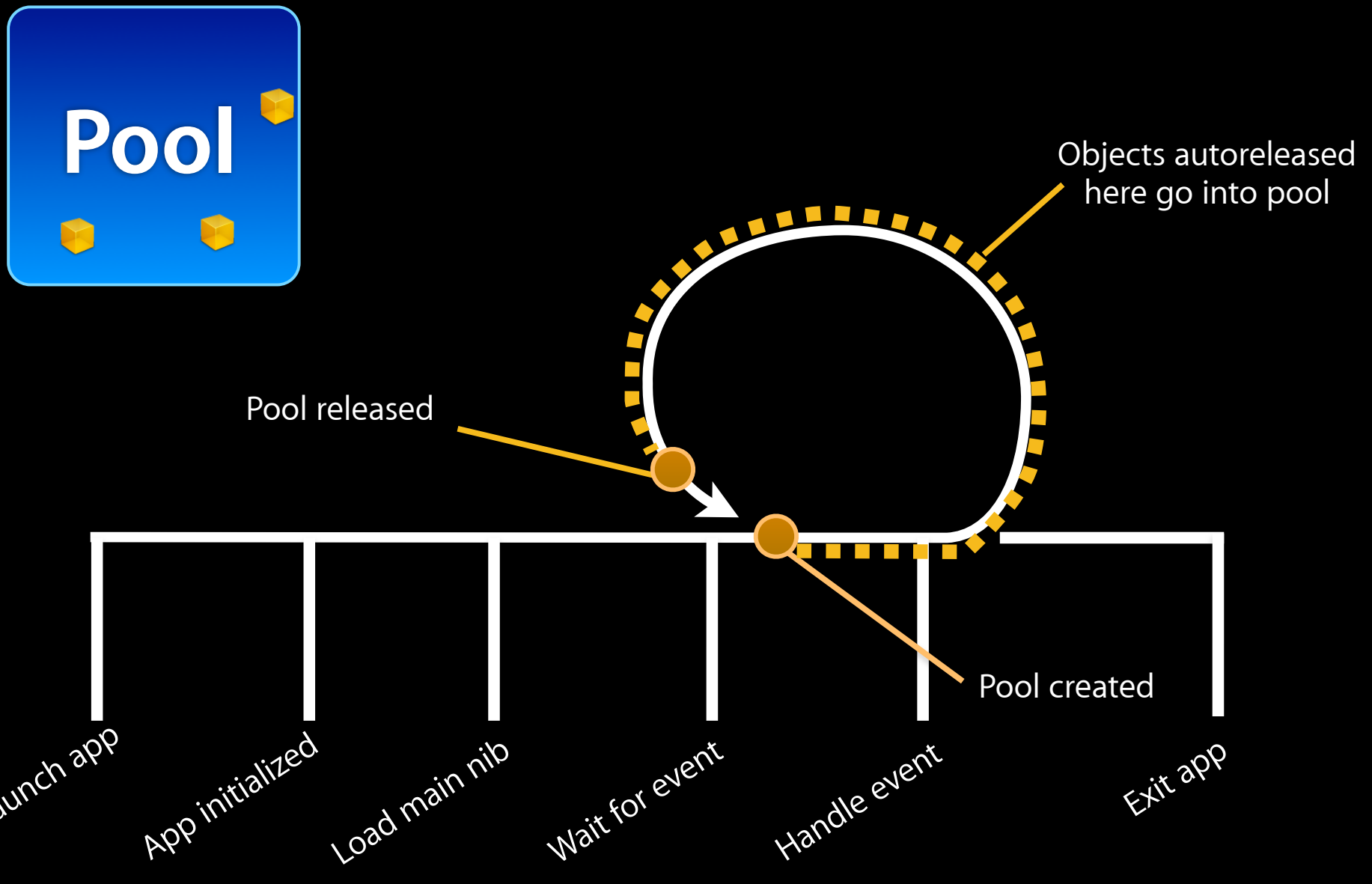

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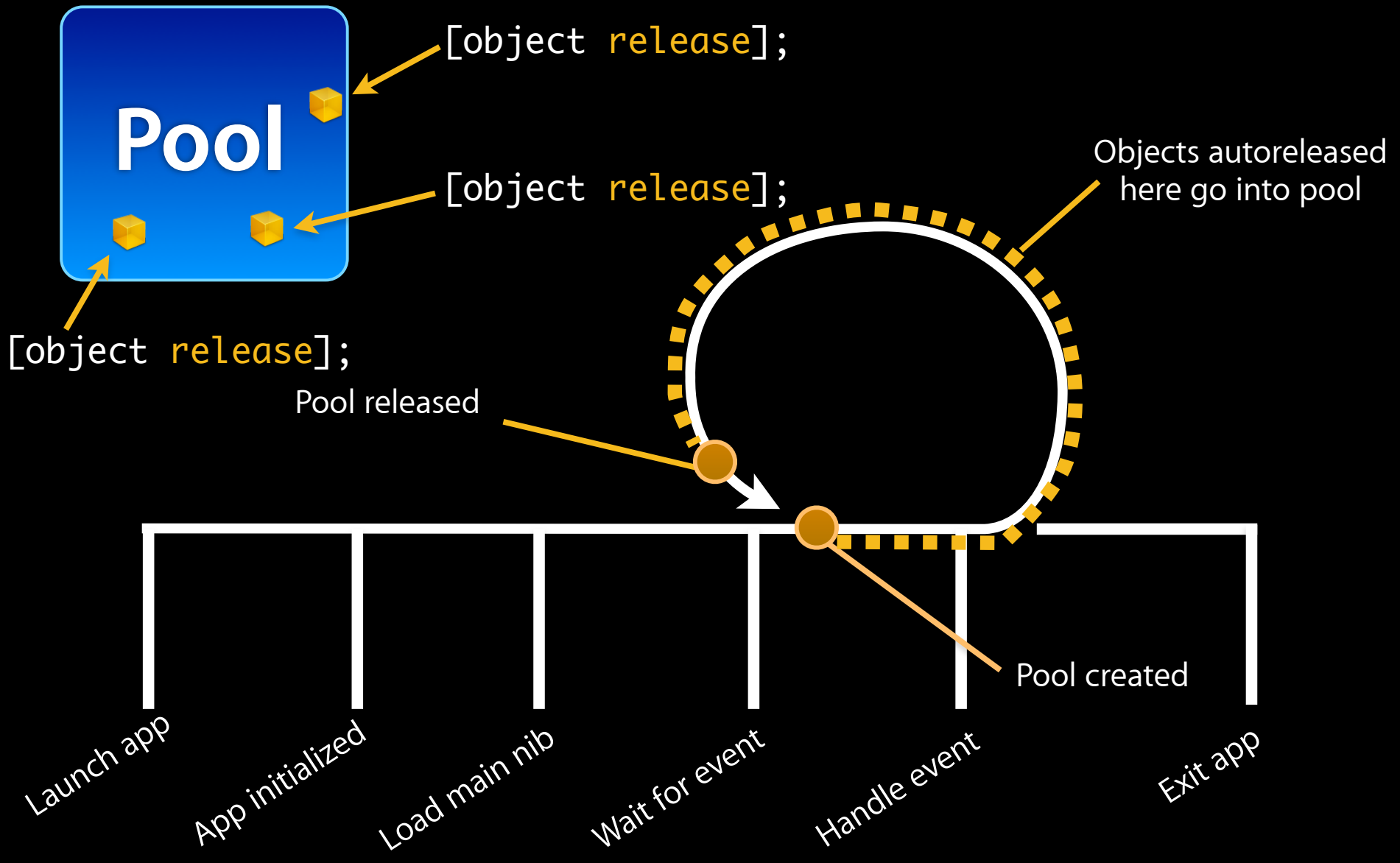

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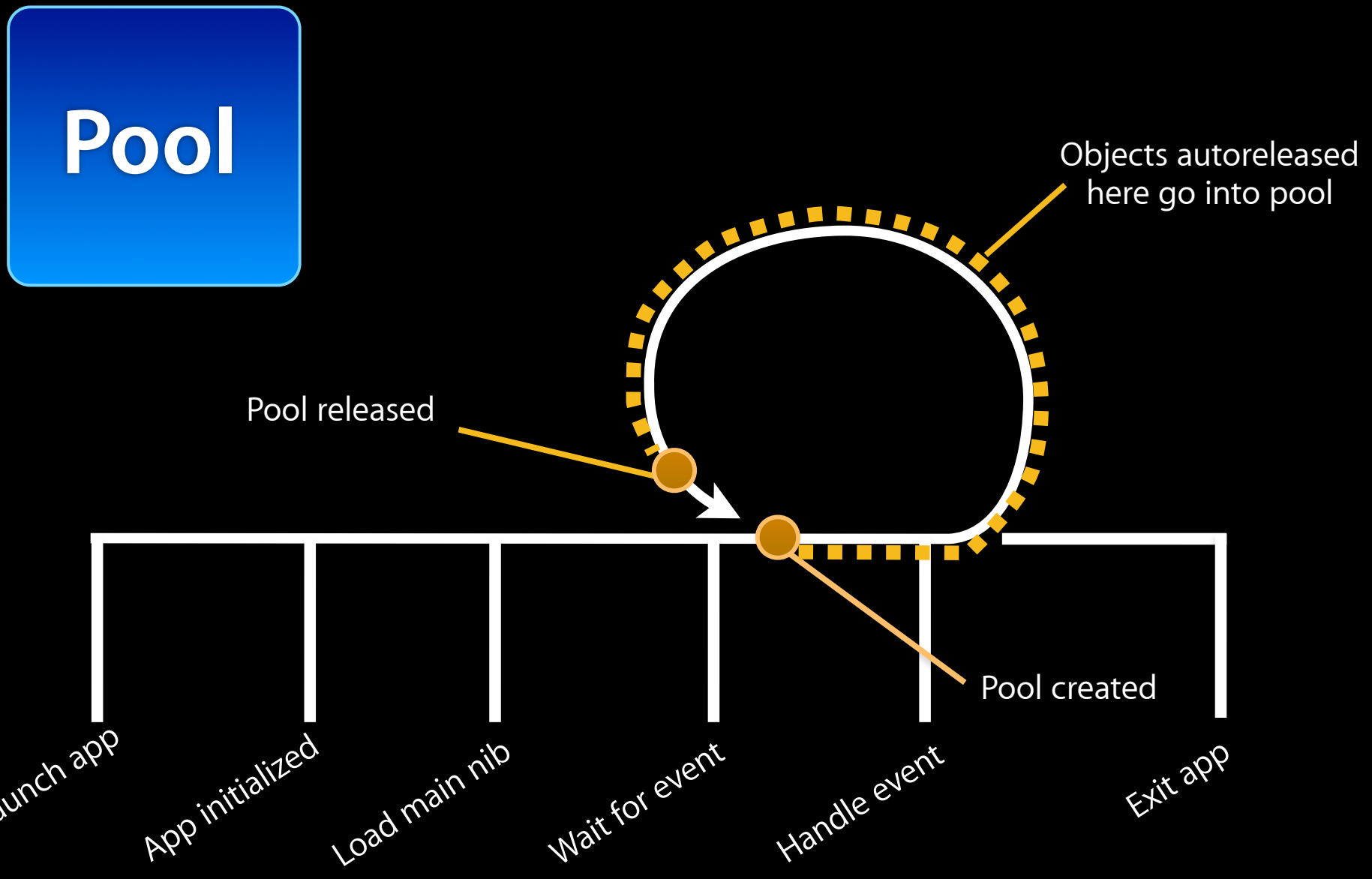

Hanging Onto an Autoreleased Object

- 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

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 does not have garbage collection

Objective-C Properties

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
```

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- (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
```

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) {
          [name release];
          name = [value copy];
     }
}
- (void)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) {
        [name release];
        name = [value copy];
    }
}
- (void)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) {
        [name release];
        name = [value copy];
    }
}

- (void)canLegallyVote { ...
```

Synthesizing Properties

```
@implementation Person

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

@end
```

Property Attributes

- Read-only versus read-write

```
@property int age;  // read-write by default
@property (readonly) BOOL canLegallyVote;
```

- Memory management policies (only for object properties)

```
@property (assign) NSString *name; // pointer assignment
@property (retain) NSString *name; // retain called
@property (copy) NSString *name;   // copy called
```

Property Names vs. Instance Variables

- Property name can be different than instance variable

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

@property int age;

@end
```

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;

    // now do something with the new 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

Dot Syntax and self

- When used in custom methods, be careful with dot syntax for properties defined in your class
- References to properties and ivars behave very differently

```
@interface Person : NSObject
{
    NSString *name;
}
@property (copy) NSString *name;
@end
```

Dot Syntax and self

- When used in custom methods, be careful with dot syntax for properties defined in your class
- References to properties and ivars behave very differently

```
@interface Person : NSObject
{
    NSString *name;
}
@property (copy) NSString *name;
@end

@implementation Person
- (void)doSomething {
    name = @“Fred”;          // accesses ivar directly!
    self.name = @“Fred”;     // calls accessor method
}
```

Common Pitfall with Dot Syntax

What will happen when this code executes?

```
@implementation Person
- (void)setAge:(int)newAge {
    self.age = newAge;
}
@end
```

Common Pitfall with Dot Syntax

What will happen when this code executes?

```
@implementation Person
- (void)setAge:(int)newAge {
    self.age = newAge;
}
@end
```

This is equivalent to:

```
@implementation Person
- (void)setAge:(int)newAge {
    [self setAge:newAge]; // Infinite loop!
}
@end
```

Further Reading

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

Questions?