Developer

#WWDC17

App Startup Time: Past, Present, and Future

Session 413

Louis Gerbarg, Senior Linker Engineer

Review of app launch startup advice

New tools to help find slow initializers

Brief history of dyld

The all new dyld that is coming in this years Apple OS platforms

Best practices

Preamble

Preamble

We want your feedback

Preamble

We want your feedback

- Please file bug reports with “DYLD USAGE:” in the title

Preamble

We want your feedback

- Please file bug reports with “DYLD USAGE:” in the title

Terminology

Preamble

We want your feedback

- Please file bug reports with “DYLD USAGE:” in the title

Terminology

- Startup time

Preamble

We want your feedback

- Please file bug reports with “DYLD USAGE:” in the title

Terminology

- Startup time
  - For the purposes of this talk startup time is everything that happens before main() is called

Preamble

We want your feedback

- Please file bug reports with “DYLD USAGE:” in the title

Terminology

- Startup time
  - For the purposes of this talk startup time is everything that happens before main() is called
- Launch Closure

Preamble

We want your feedback

- Please file bug reports with “DYLD USAGE:” in the title

Terminology

- Startup time
  - For the purposes of this talk startup time is everything that happens before main() is called
- Launch Closure
  - All of the information necessary to launch an application

Improving App Startup Time

Improving App Startup Time

Do less!

Improving App Startup Time

Do less!

- Embed fewer dylibs

Improving App Startup Time

Do less!

- Embed fewer dylibs
- Declare fewer classes/methods

Improving App Startup Time

Do less!

- Embed fewer dylibs
- Declare fewer classes/methods
- Use fewer initializers

Improving App Startup Time

Do less!

- Embed fewer dylibs
- Declare fewer classes/methods
- Use fewer initializers

Use more Swift

Improving App Startup Time

Do less!

- Embed fewer dylibs
- Declare fewer classes/methods
- Use fewer initializers

Use more Swift

- No initializers

Improving App Startup Time

Do less!

- Embed fewer dylibs
- Declare fewer classes/methods
- Use fewer initializers

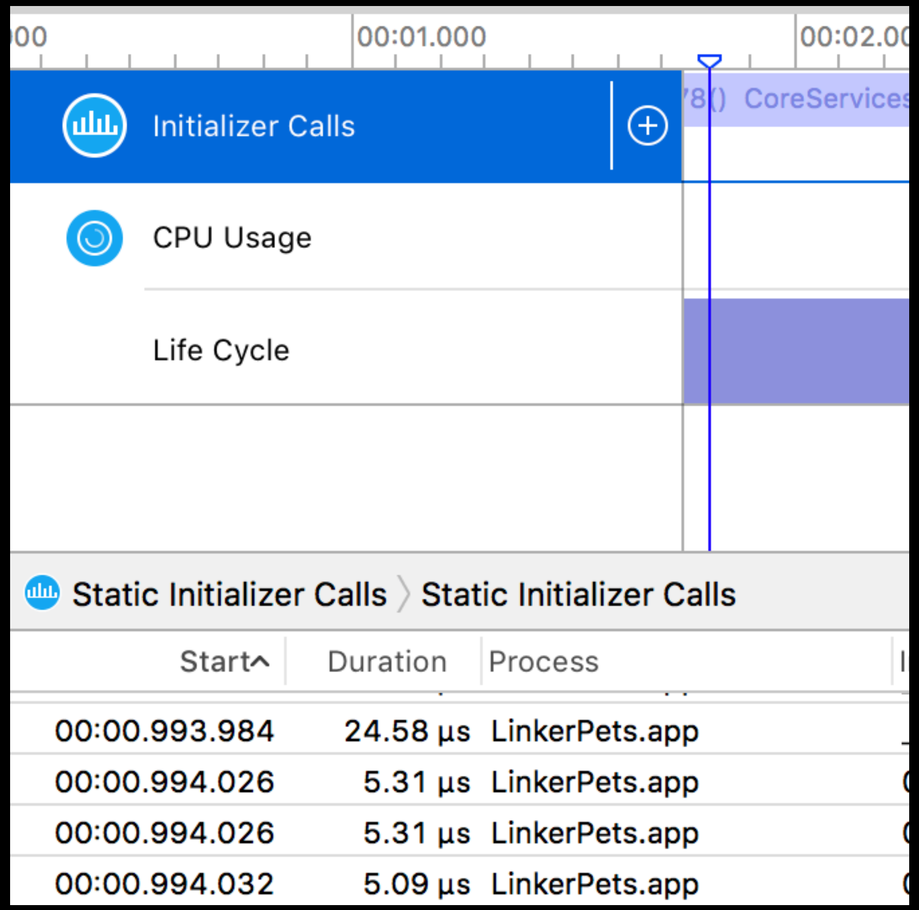
Use more Swift

- No initializers
- Swift size improvements

Improving App Startup Time

Static initializer tracing

NEW

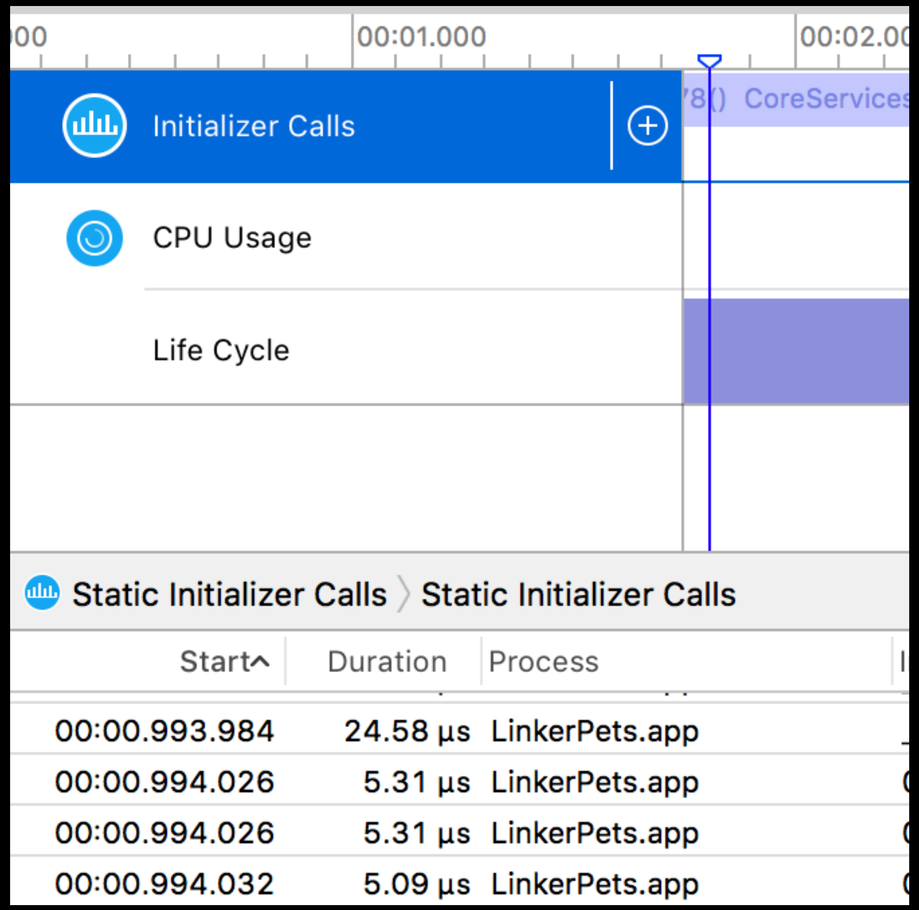


Improving App Startup Time

Static initializer tracing

NEW

New in iOS 11 and macOS High Sierra



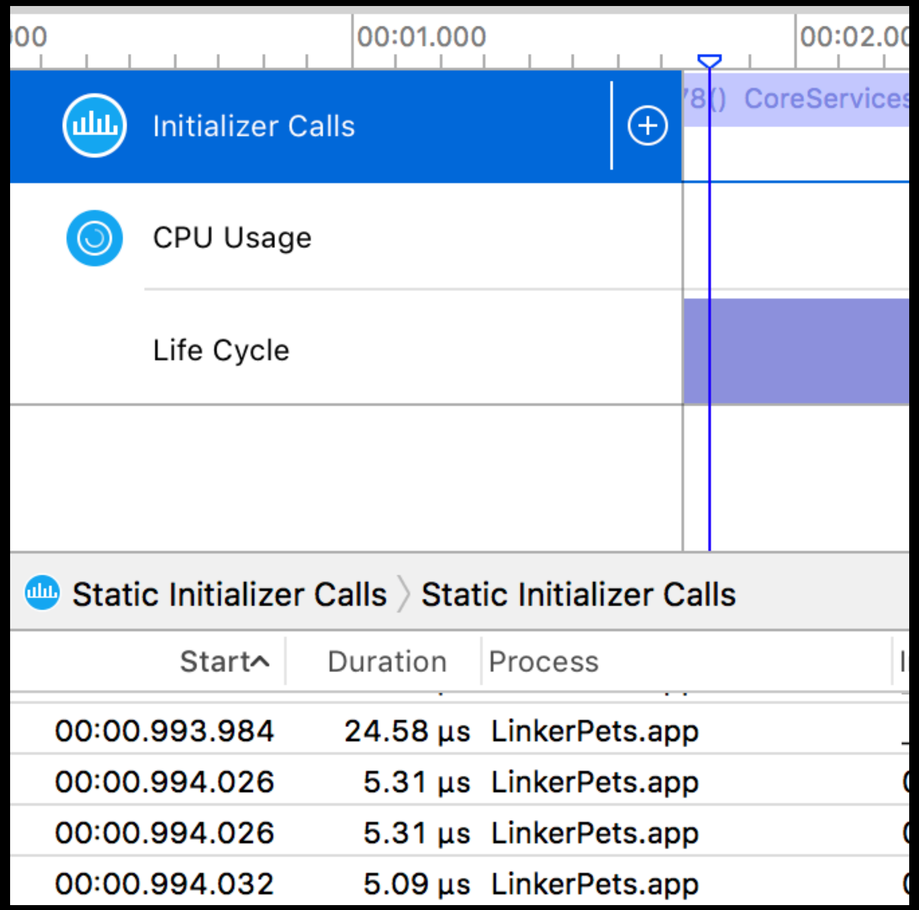
Improving App Startup Time

Static initializer tracing

NEW

New in iOS 11 and macOS High Sierra

Provides precise timing for each static initializer



Improving App Startup Time

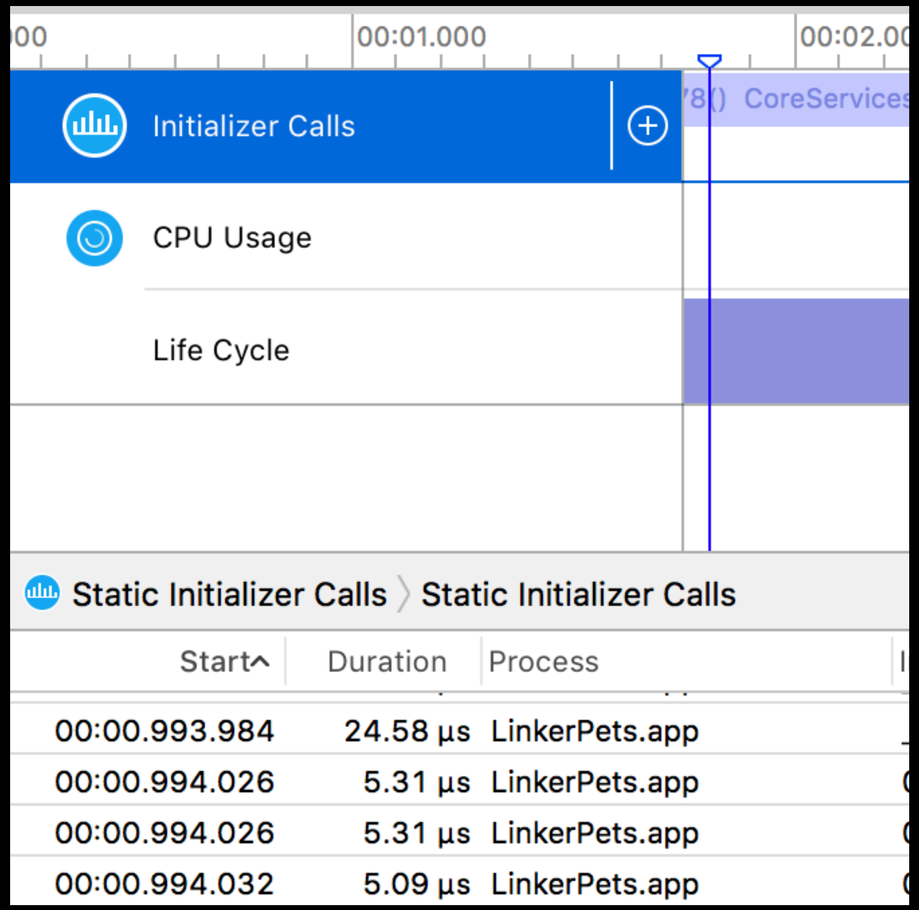
Static initializer tracing

NEW

New in iOS 11 and macOS High Sierra

Provides precise timing for each static initializer

Available through Instruments



Improving App Startup Time

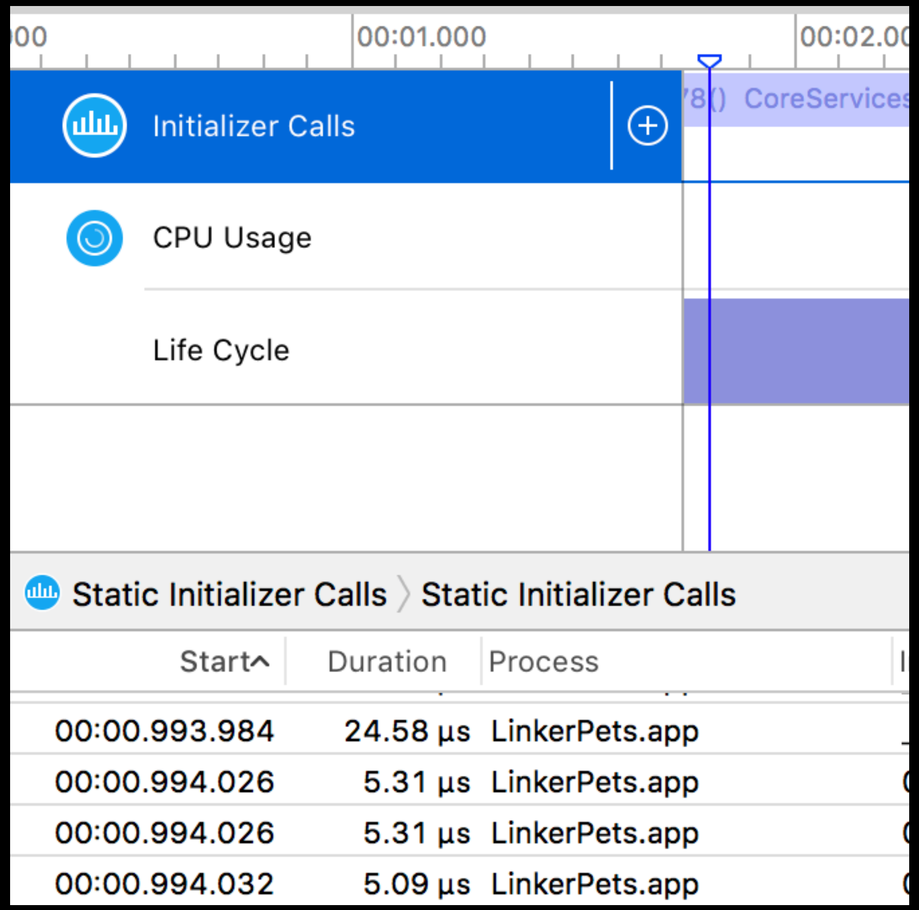
Static initializer tracing

NEW

New in iOS 11 and macOS High Sierra

Provides precise timing for each static initializer

Available through Instruments



Demo

Dynamic Linking Through the Ages

dyld 1.0 (1996–2004)

Dynamic Linking Through the Ages

dyld 1.0 (1996–2004)

Shipped in NeXTStep 3.3

Dynamic Linking Through the Ages

dyld 1.0 (1996–2004)

Shipped in NeXTStep 3.3

Predated POSIX dlopen() standardized

Dynamic Linking Through the Ages

dyld 1.0 (1996–2004)

Shipped in NeXTStep 3.3

Predated POSIX dlopen() standardized

- Third-party wrapper functions

Dynamic Linking Through the Ages

dyld 1.0 (1996–2004)

Shipped in NeXTStep 3.3

Predated POSIX dlopen() standardized

- Third-party wrapper functions

Before most systems used large C++ dynamic libraries

Dynamic Linking Through the Ages

dyld 1.0 (1996–2004)

Shipped in NeXTStep 3.3

Predated POSIX dlopen() standardized

- Third-party wrapper functions

Before most systems used large C++ dynamic libraries

Prebinding added in macOS Cheetah (10.0)

Dynamic Linking Through the Ages

dyld 2.0 (2004–2007)

Dynamic Linking Through the Ages

dyld 2.0 (2004–2007)

Shipped in macOS Tiger

Dynamic Linking Through the Ages

dyld 2.0 (2004–2007)

Shipped in macOS Tiger

Complete rewrite

Dynamic Linking Through the Ages

dyld 2.0 (2004–2007)

Shipped in macOS Tiger

Complete rewrite

- Correct C++ initializer semantics

Dynamic Linking Through the Ages

dyld 2.0 (2004–2007)

Shipped in macOS Tiger

Complete rewrite

- Correct C++ initializer semantics
- Full native dlopen()/dlsym() semantics

Dynamic Linking Through the Ages

dyld 2.0 (2004–2007)

Shipped in macOS Tiger

Complete rewrite

- Correct C++ initializer semantics
- Full native dlopen()/dlsym() semantics

Designed for speed

Dynamic Linking Through the Ages

dyld 2.0 (2004–2007)

Shipped in macOS Tiger

Complete rewrite

- Correct C++ initializer semantics
- Full native dlopen()/dlsym() semantics

Designed for speed

- Limited sanity checking

Dynamic Linking Through the Ages

dyld 2.0 (2004–2007)

Shipped in macOS Tiger

Complete rewrite

- Correct C++ initializer semantics
- Full native dlopen()/dlsym() semantics

Designed for speed

- Limited sanity checking
- Security “Issues”

Dynamic Linking Through the Ages

dyld 2.0 (2004–2007)

Shipped in macOS Tiger

Complete rewrite

- Correct C++ initializer semantics
- Full native dlopen()/dlsym() semantics

Designed for speed

- Limited sanity checking
- Security “Issues”

Reduced prebinding

Dynamic Linking Through the Ages

dyld 2.x (2007–2017)

Dynamic Linking Through the Ages

dyld 2.x (2007–2017)

More architectures and platforms

Dynamic Linking Through the Ages

dyld 2.x (2007–2017)

More architectures and platforms

- x86, x86_64, arm, arm64

Dynamic Linking Through the Ages

dyld 2.x (2007–2017)

More architectures and platforms

- x86, x86_64, arm, arm64
- iOS, tvOS, watchOS

Dynamic Linking Through the Ages

dyld 2.x (2007–2017)

More architectures and platforms

- x86, x86_64, arm, arm64
- iOS, tvOS, watchOS

Improved security

Dynamic Linking Through the Ages

dyld 2.x (2007–2017)

More architectures and platforms

- x86, x86_64, arm, arm64
- iOS, tvOS, watchOS

Improved security

- Codesigning, ASLR, bounds checking

Dynamic Linking Through the Ages

dyld 2.x (2007–2017)

More architectures and platforms

- x86, x86_64, arm, arm64
- iOS, tvOS, watchOS

Improved security

- Codesigning, ASLR, bounds checking

Improved performance

Dynamic Linking Through the Ages

dyld 2.x (2007–2017)

More architectures and platforms

- x86, x86_64, arm, arm64
- iOS, tvOS, watchOS

Improved security

- Codesigning, ASLR, bounds checking

Improved performance

- Prebinding completely replaced by shared cache

Dynamic Linking Through the Ages

Shared Cache

Dynamic Linking Through the Ages

Shared Cache

Introduced in iOS 3.1 and macOS Snow Leopard

Dynamic Linking Through the Ages

Shared Cache

Introduced in iOS 3.1 and macOS Snow Leopard

- Replaced prebinding

Dynamic Linking Through the Ages

Shared Cache

Introduced in iOS 3.1 and macOS Snow Leopard

- Replaced prebinding

Single file that contains most system dylibs

Dynamic Linking Through the Ages

Shared Cache

Introduced in iOS 3.1 and macOS Snow Leopard

- Replaced prebinding

Single file that contains most system dylibs

- Rearranges binaries to improve load speed

Dynamic Linking Through the Ages

Shared Cache

Introduced in iOS 3.1 and macOS Snow Leopard

- Replaced prebinding

Single file that contains most system dylibs

- Rearranges binaries to improve load speed
- Pre-links dylibs

Dynamic Linking Through the Ages

Shared Cache

Introduced in iOS 3.1 and macOS Snow Leopard

- Replaced prebinding

Single file that contains most system dylibs

- Rearranges binaries to improve load speed
- Pre-links dylibs
- Pre-builds data structures used dyld and ObjC

Dynamic Linking Through the Ages

Shared Cache

Introduced in iOS 3.1 and macOS Snow Leopard

- Replaced prebinding

Single file that contains most system dylibs

- Rearranges binaries to improve load speed
- Pre-links dylibs
- Pre-builds data structures used dyld and ObjC

Built locally on macOS, shipped as part of all other Apple OS platforms

Dynamic Linking Through the Ages

dyld 3 (2017)

Dynamic Linking Through the Ages

dyld 3 (2017)

Announcing it today

Dynamic Linking Through the Ages

dyld 3 (2017)

Announcing it today

Complete rethink of dynamic linking

Dynamic Linking Through the Ages

dyld 3 (2017)

Announcing it today

Complete rethink of dynamic linking

On by default for most macOS system apps in this weeks seed

Dynamic Linking Through the Ages

dyld 3 (2017)

Announcing it today

Complete rethink of dynamic linking

On by default for most macOS system apps in this weeks seed

Will be on be the default for system apps for 2017 Apple OS platforms

Dynamic Linking Through the Ages

dyld 3 (2017)

Announcing it today

Complete rethink of dynamic linking

On by default for most macOS system apps in this weeks seed

Will be on be the default for system apps for 2017 Apple OS platforms

Will completely replace dyld 2.x in future Apple OS platforms

dyld 3

Why?

dyld 3

Why?

Performance

dyld 3

Why?

Performance

- What is the minimum amount of work we can do to start an app?

dyld 3

Why?

Performance

- What is the minimum amount of work we can do to start an app?

Security

dyld 3

Why?

Performance

- What is the minimum amount of work we can do to start an app?

Security

- Can we have more aggressive security checks?

dyld 3

Why?

Performance

- What is the minimum amount of work we can do to start an app?

Security

- Can we have more aggressive security checks?

Reliability

dyld 3

Why?

Performance

- What is the minimum amount of work we can do to start an app?

Security

- Can we have more aggressive security checks?

Reliability

- Can we design something that is easier to test?

dyld 3

How?

dyld 3

How?

Move complex operations out of process

dyld 3

How?

Move complex operations out of process

- Most of dyld is now a regular daemon

dyld 3

How?

Move complex operations out of process

- Most of dyld is now a regular daemon

Make the rest of dyld as small as possible

dyld 3

How?

Move complex operations out of process

- Most of dyld is now a regular daemon

Make the rest of dyld as small as possible

- Reduces attack surface

dyld 3

How?

Move complex operations out of process

- Most of dyld is now a regular daemon

Make the rest of dyld as small as possible

- Reduces attack surface
- Speeds up launch

dyld 3

How?

Move complex operations out of process

- Most of dyld is now a regular daemon

Make the rest of dyld as small as possible

- Reduces attack surface
- Speeds up launch
  - The fastest code is code you never write

dyld 3

How?

Move complex operations out of process

- Most of dyld is now a regular daemon

Make the rest of dyld as small as possible

- Reduces attack surface
- Speeds up launch
  - The fastest code is code you never write
  - Followed closely by code you almost never execute

dyld 3

How?

Move complex operations out of process

- Most of dyld is now a regular daemon

Make the rest of dyld as small as possible

- Reduces attack surface
- Speeds up launch
  - The fastest code is code you never write
  - Followed closely by code you almost never execute

dyld 3

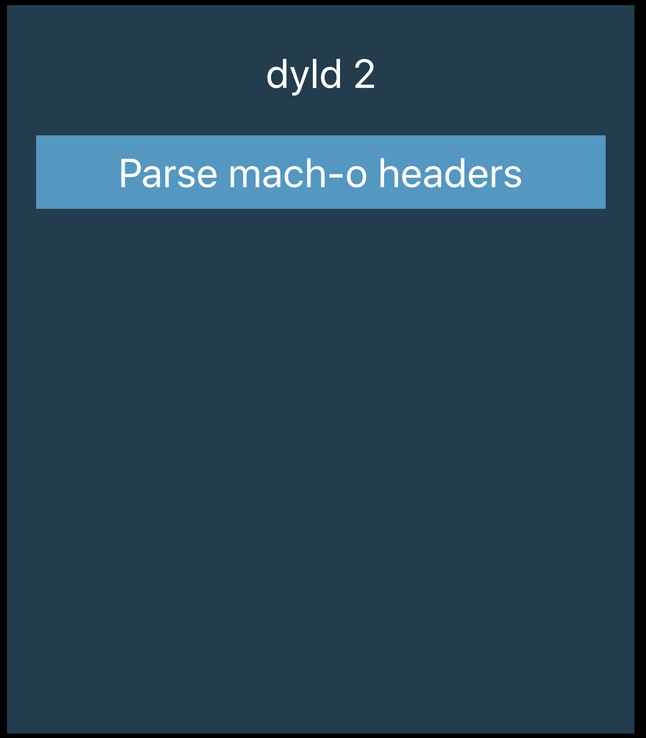
How?

Move complex operations out of process

- Most of dyld is now a regular daemon

Make the rest of dyld as small as possible

- Reduces attack surface
- Speeds up launch
  - The fastest code is code you never write
  - Followed closely by code you almost never execute



dyld 3

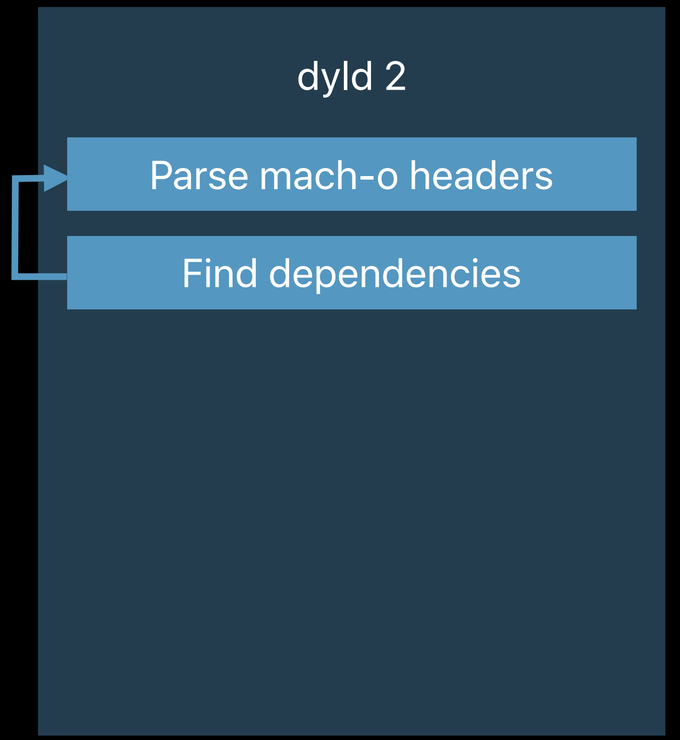
How?

Move complex operations out of process

- Most of dyld is now a regular daemon

Make the rest of dyld as small as possible

- Reduces attack surface
- Speeds up launch
  - The fastest code is code you never write
  - Followed closely by code you almost never execute



dyld 3

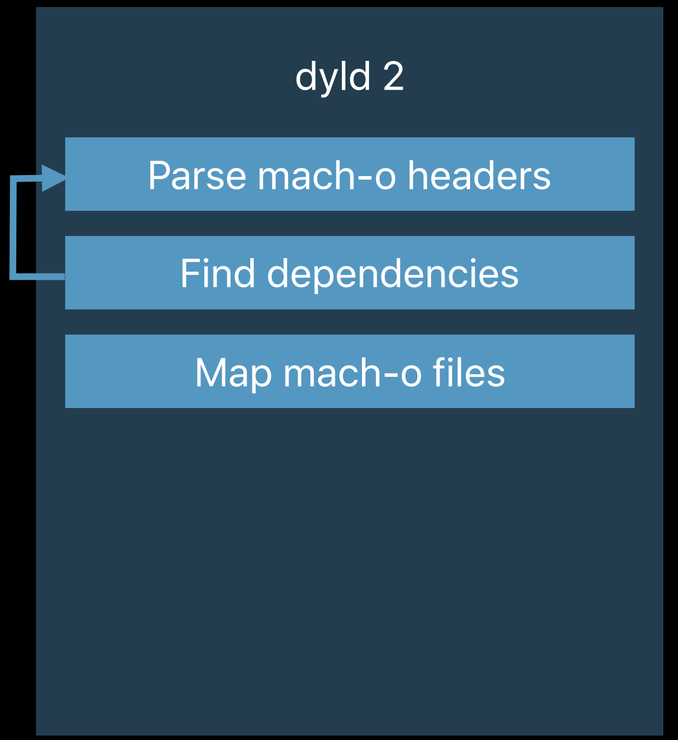
How?

Move complex operations out of process

- Most of dyld is now a regular daemon

Make the rest of dyld as small as possible

- Reduces attack surface
- Speeds up launch
  - The fastest code is code you never write
  - Followed closely by code you almost never execute



dyld 3

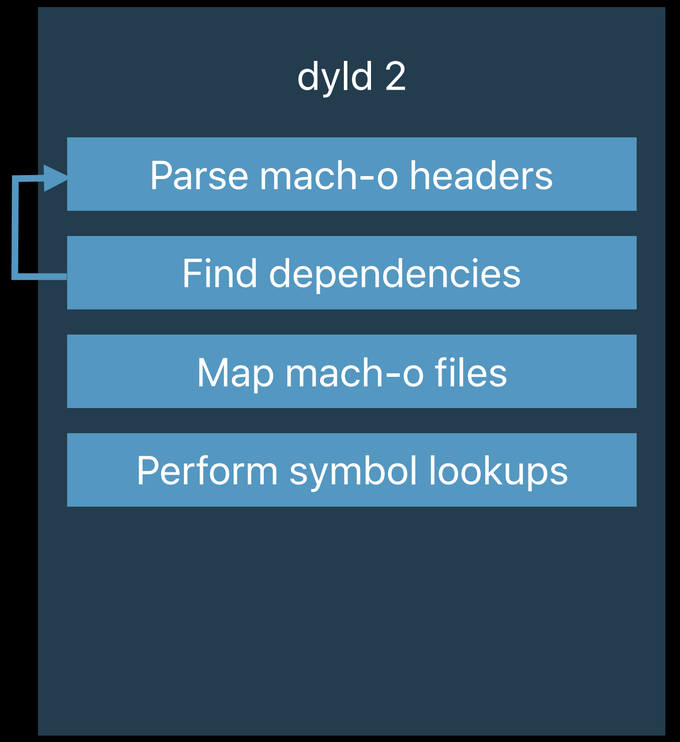
How?

Move complex operations out of process

- Most of dyld is now a regular daemon

Make the rest of dyld as small as possible

- Reduces attack surface
- Speeds up launch
  - The fastest code is code you never write
  - Followed closely by code you almost never execute



dyld 3

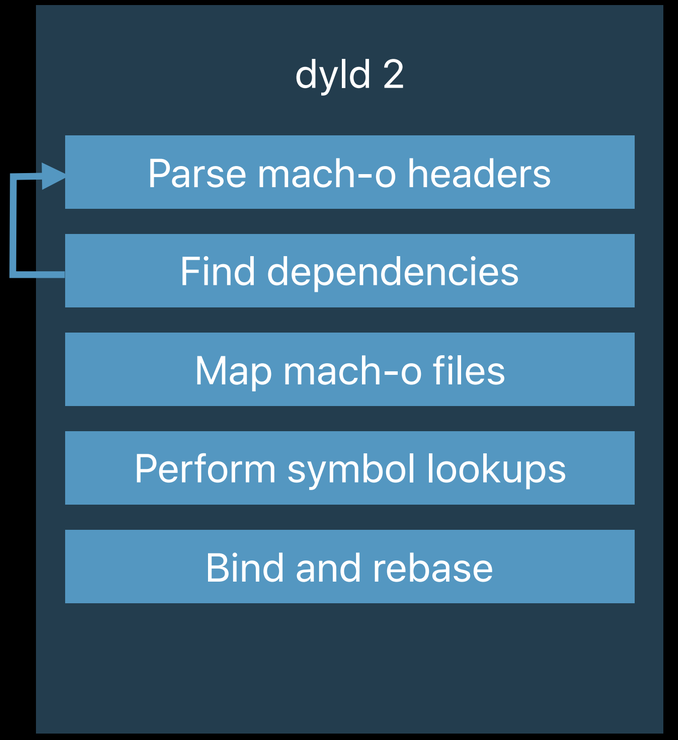
How?

Move complex operations out of process

- Most of dyld is now a regular daemon

Make the rest of dyld as small as possible

- Reduces attack surface
- Speeds up launch
  - The fastest code is code you never write
  - Followed closely by code you almost never execute



dyld 3

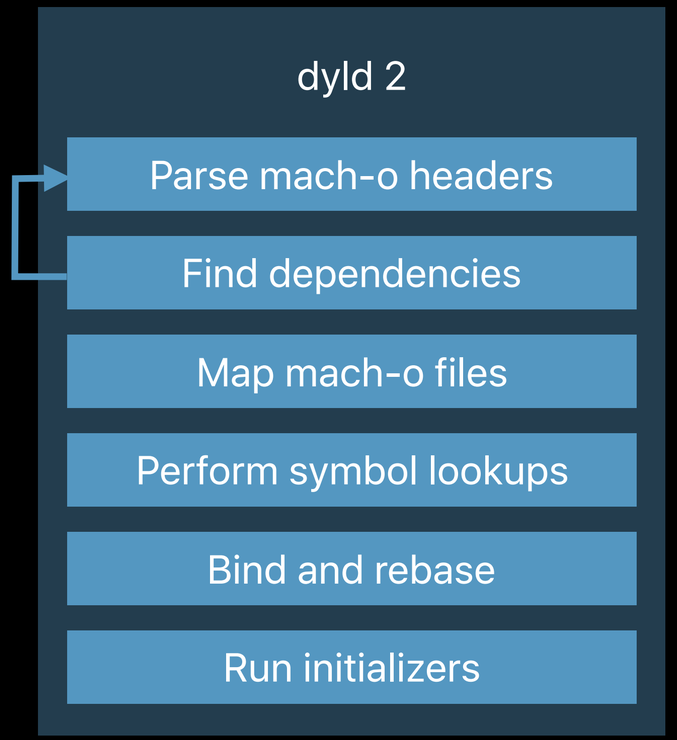
How?

Move complex operations out of process

- Most of dyld is now a regular daemon

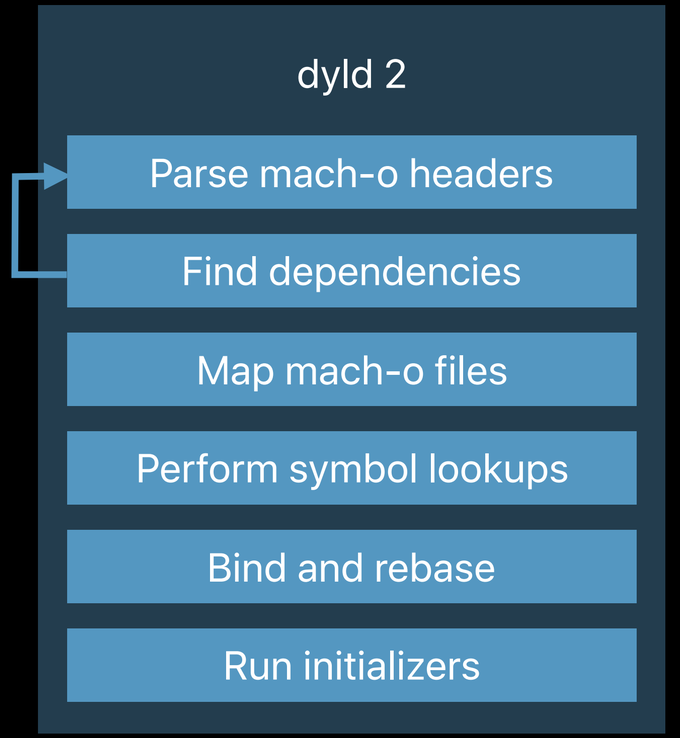
Make the rest of dyld as small as possible

- Reduces attack surface
- Speeds up launch
  - The fastest code is code you never write
  - Followed closely by code you almost never execute



dyld 3

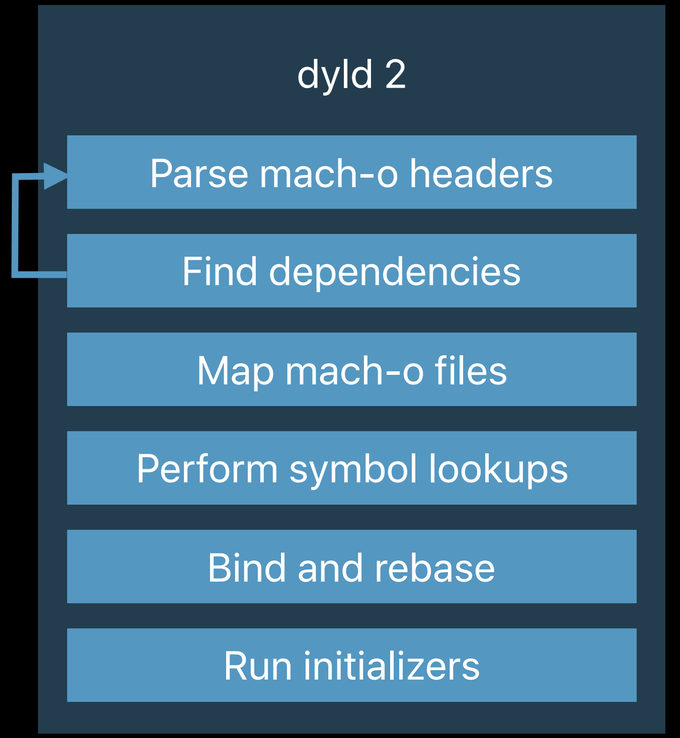
How?


dyld 2
Parse mach-o headers
Find dependencies
Map mach-o files
Perform symbol lookups
Bind and rebase
Run initializers

dyld 3

How?

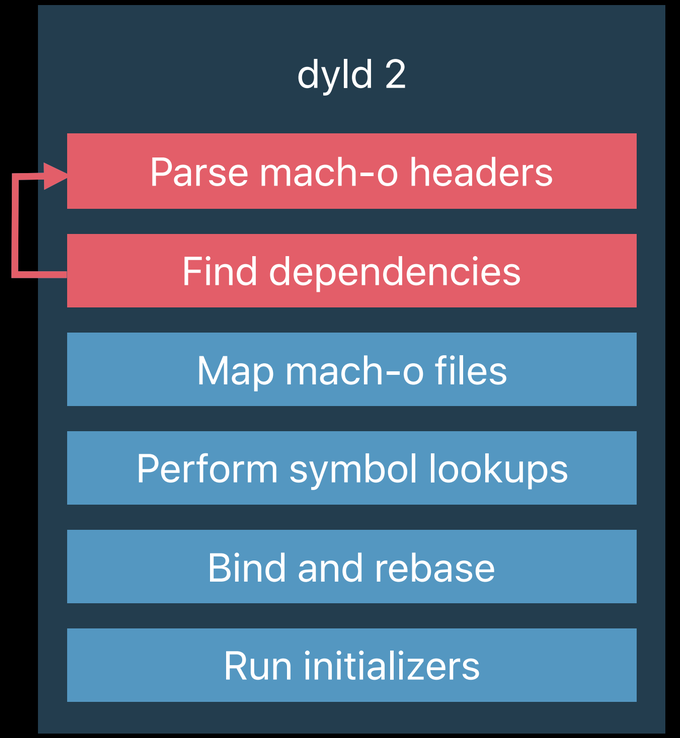
Identify security sensitive components



dyld 3

How?

Identify security sensitive components

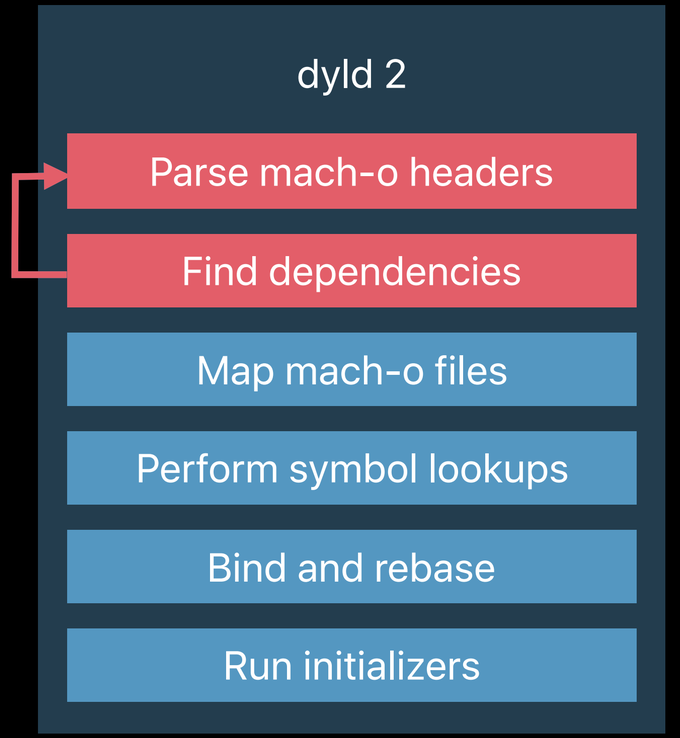


dyld 3

How?

Identify security sensitive components

- Bounds checking

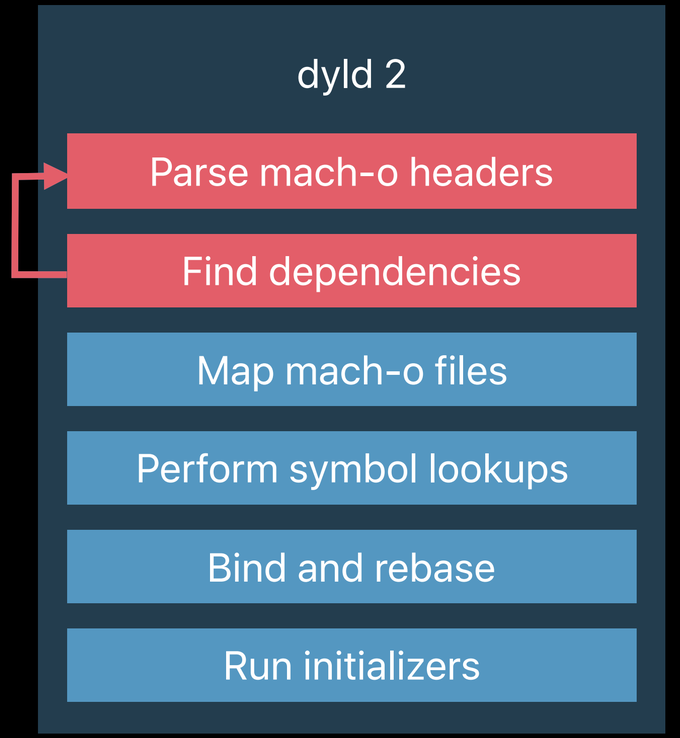


dyld 3

How?

Identify security sensitive components

- Bounds checking
- @rpath confusion attacks



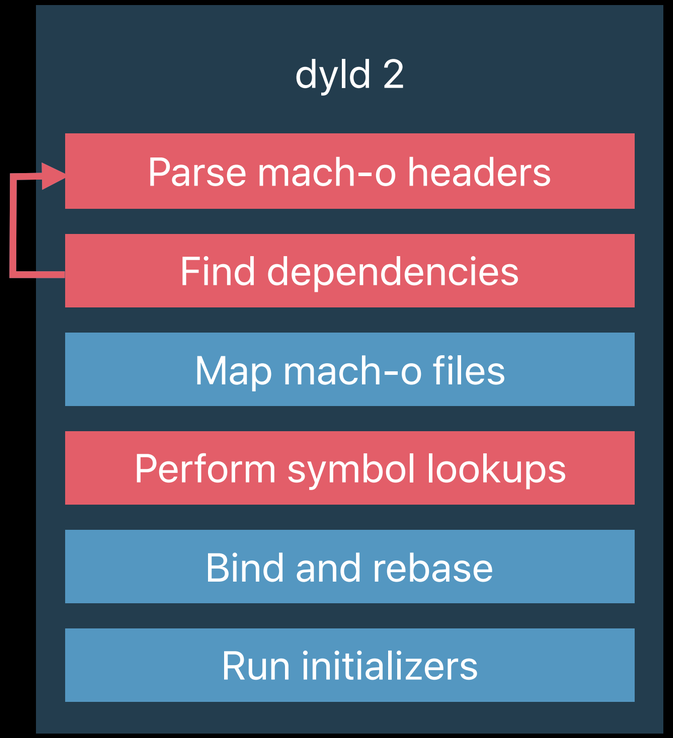
dyld 3

How?

Identify security sensitive components

- Bounds checking
- @rpath confusion attacks

Identify components that are cache-able



dyld 3

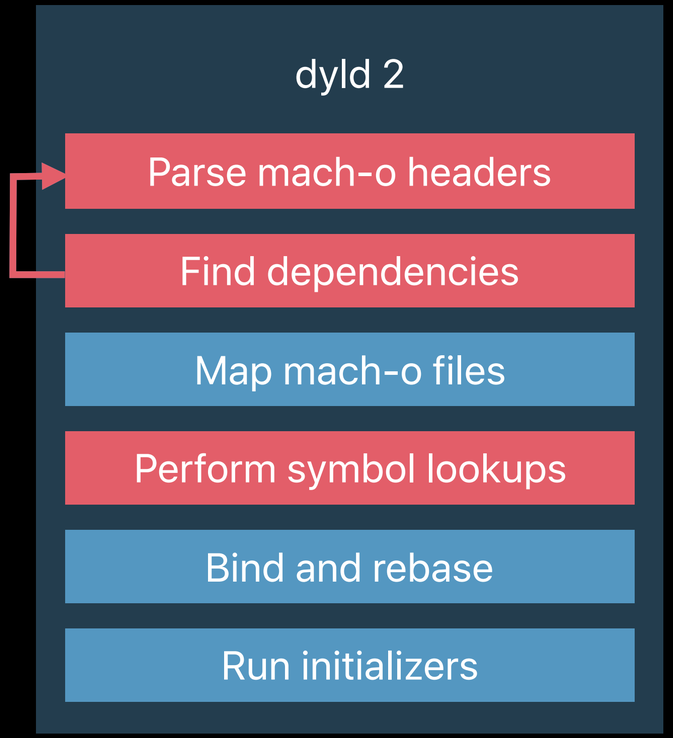
How?

Identify security sensitive components

- Bounds checking
- @rpath confusion attacks

Identify components that are cache-able

- Dependencies don’t change between launches



dyld 3

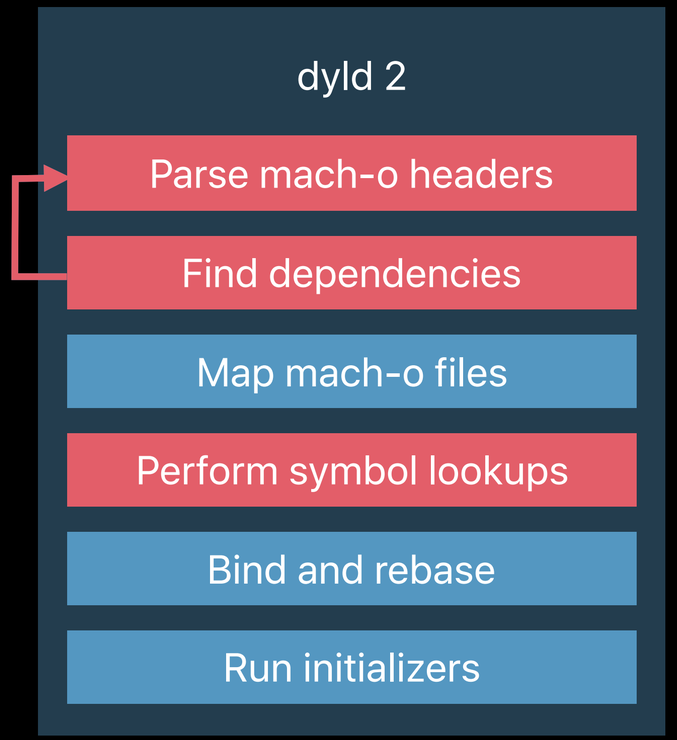
How?

Identify security sensitive components

- Bounds checking
- @rpath confusion attacks

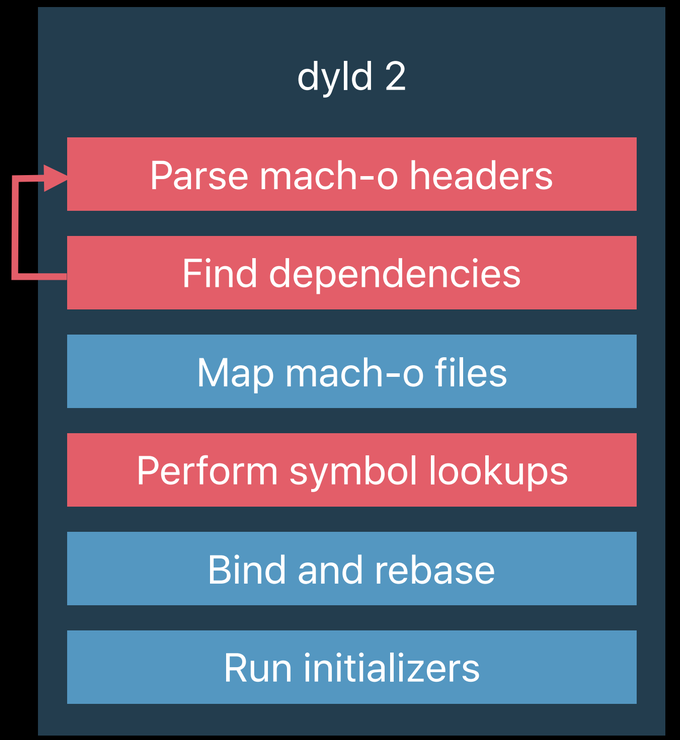
Identify components that are cache-able

- Dependencies don’t change between launches
- Symbol locations within a mach-o do not change between launches

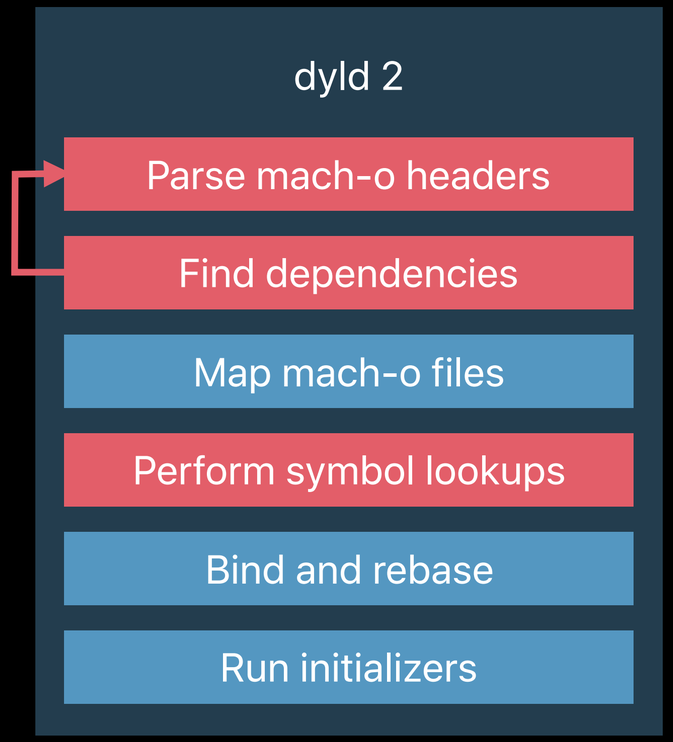


dyld 3

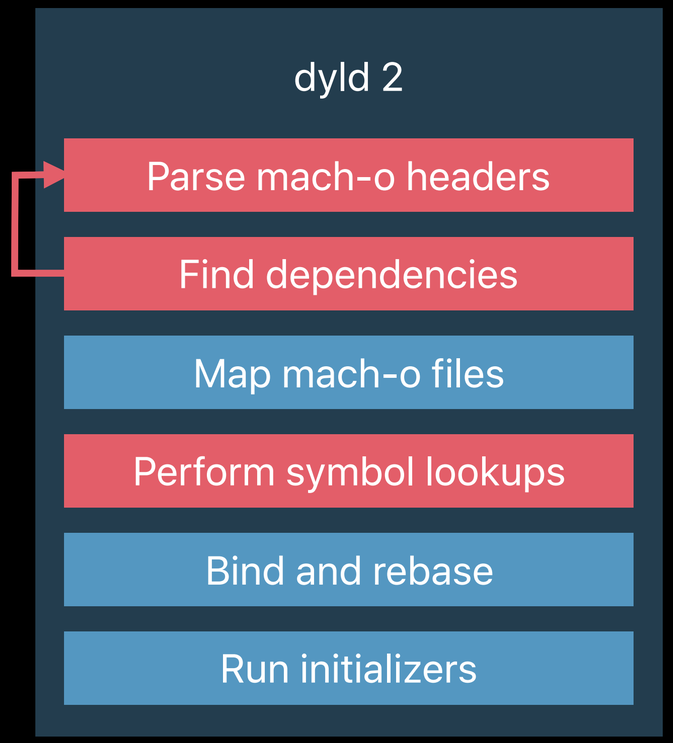
How?

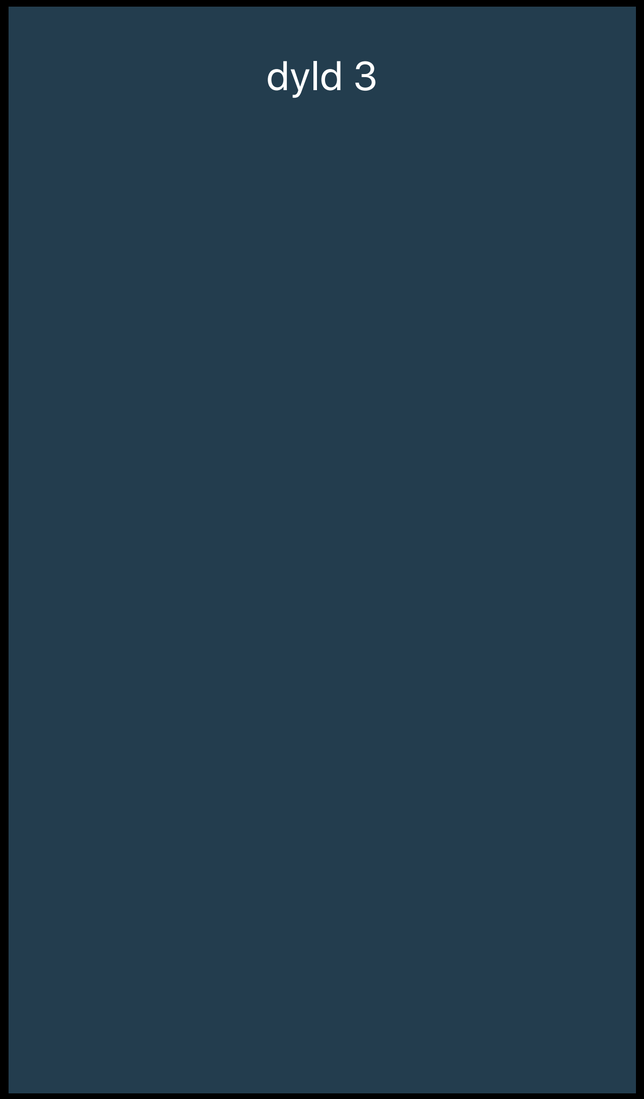

dyld 2
Parse mach-o headers
Find dependencies
Map mach-o files
Perform symbol lookups
Bind and rebase
Run initializers

dyld 3
Architecture

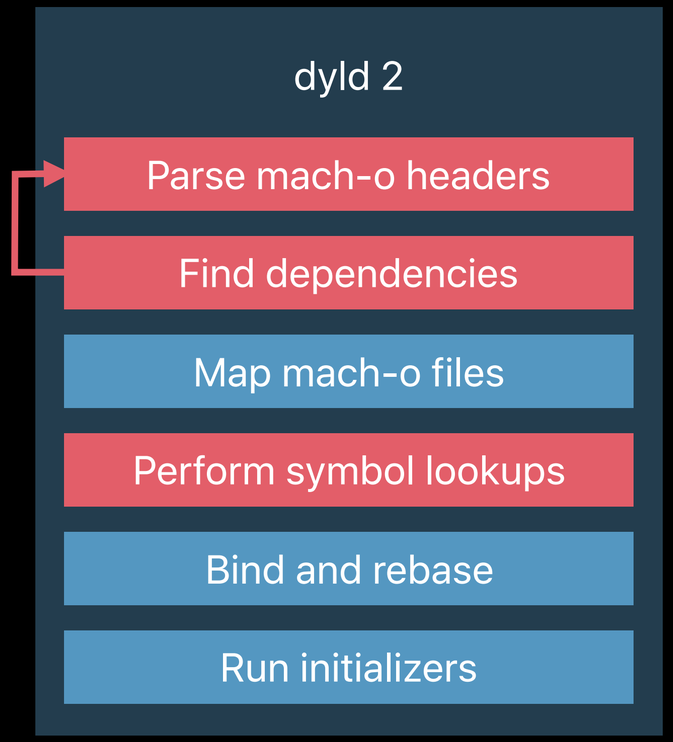


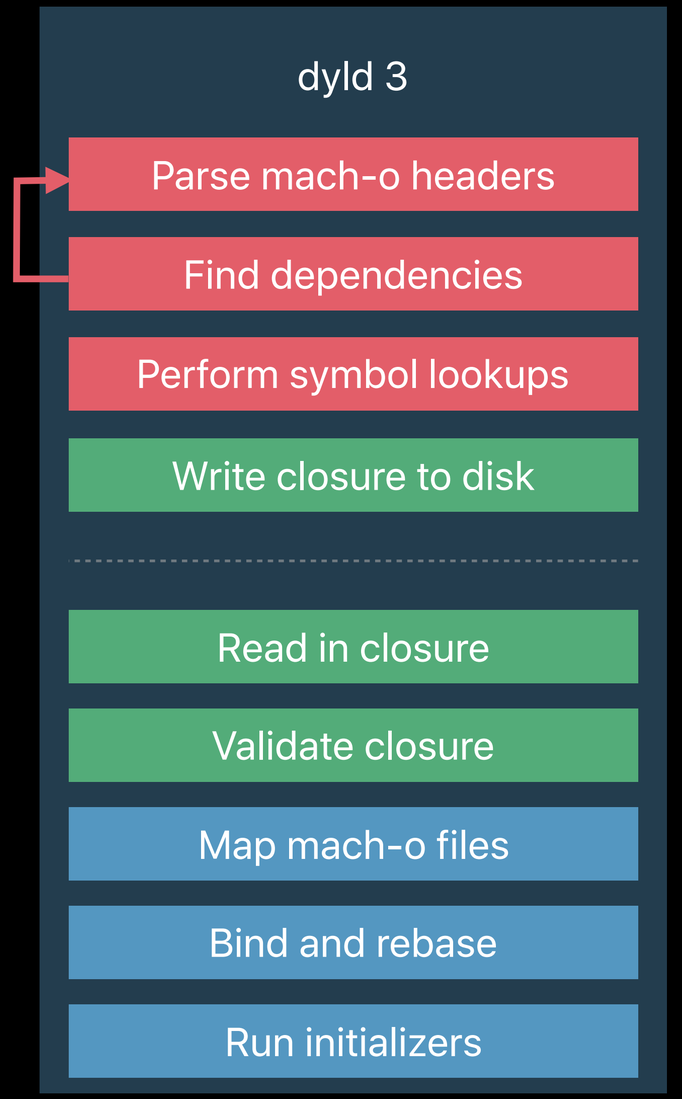
dyld 3
Architecture



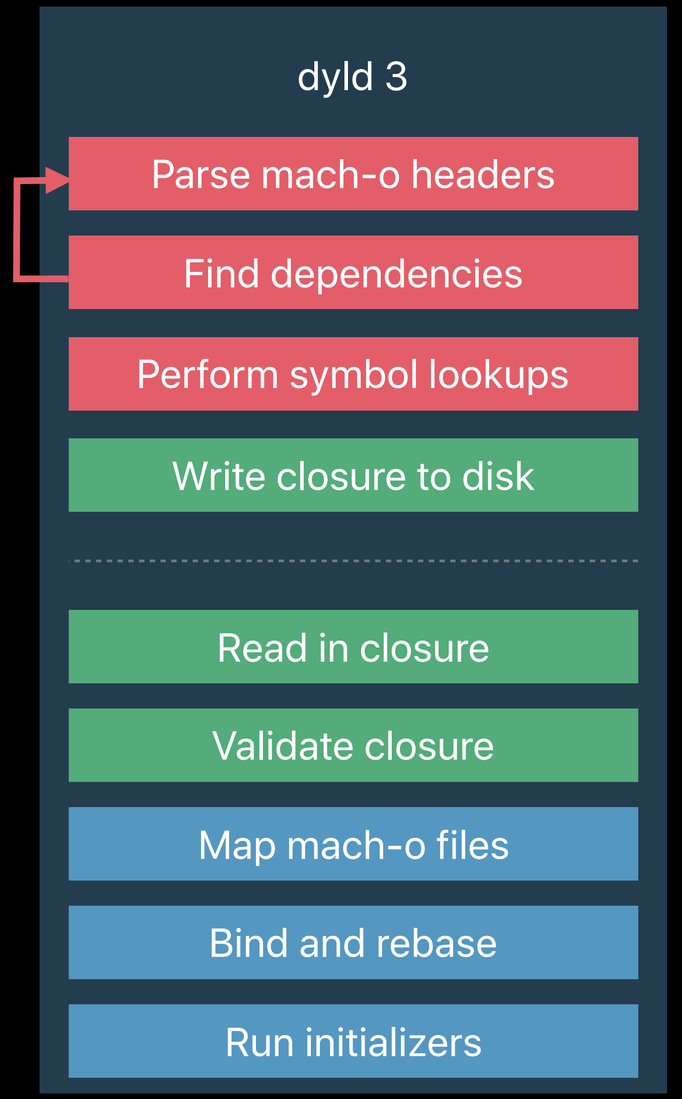


dyld 3
Architecture



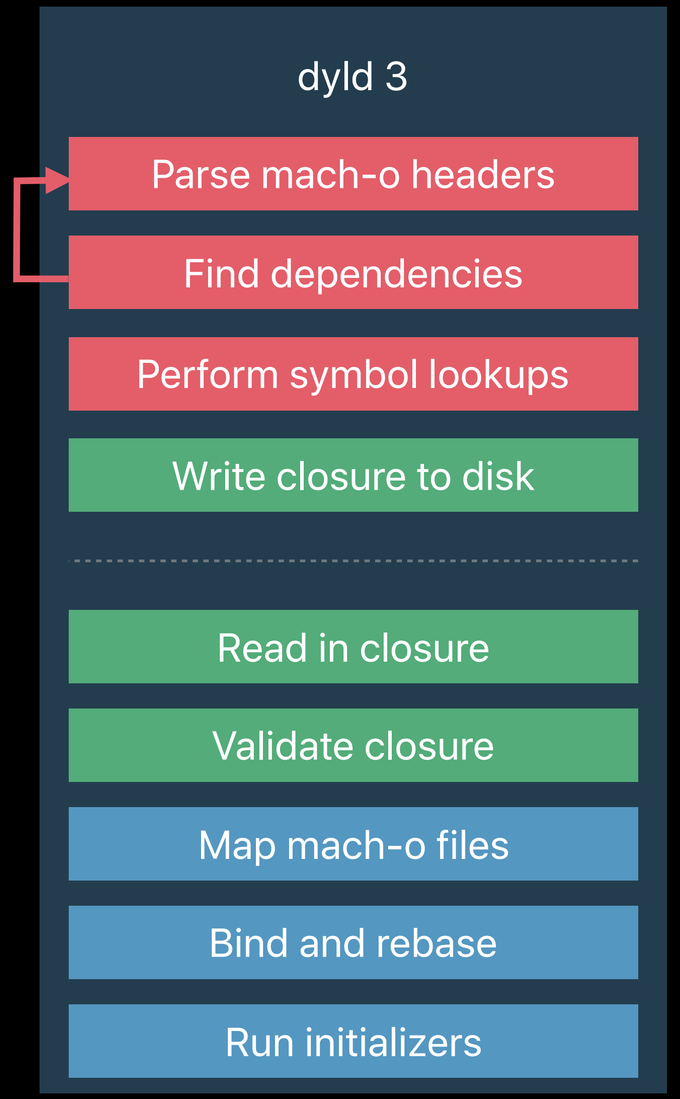


dyld 3
Architecture



dyld 3
Architecture

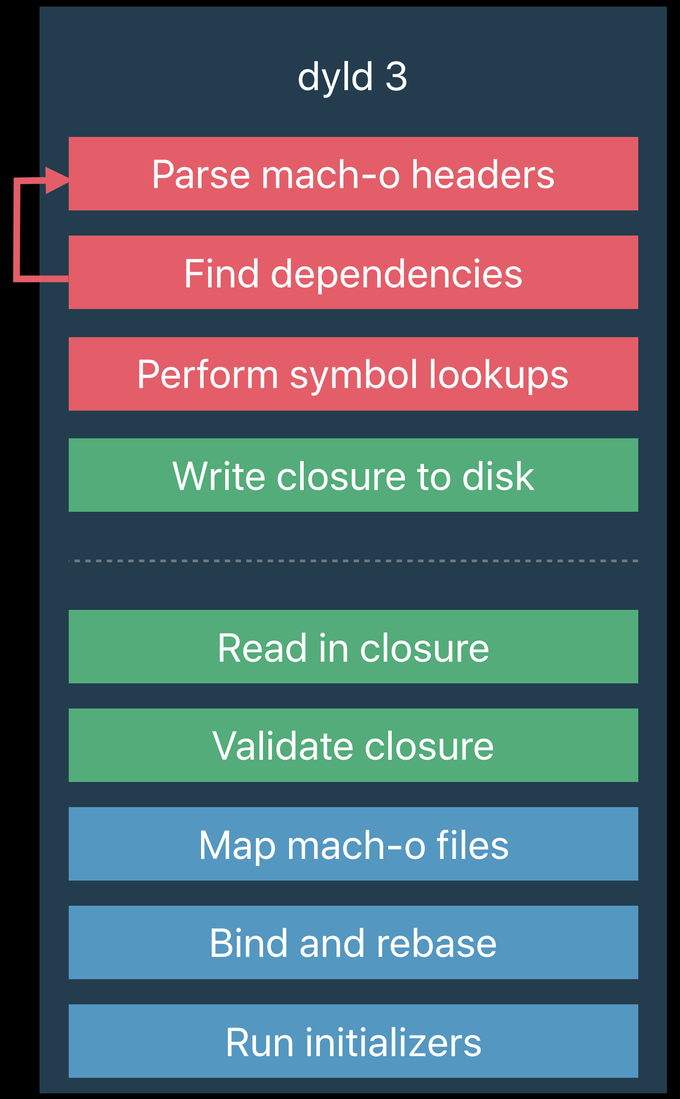
dyld 3 has 3 components



dyld 3
Architecture

dyld 3 has 3 components

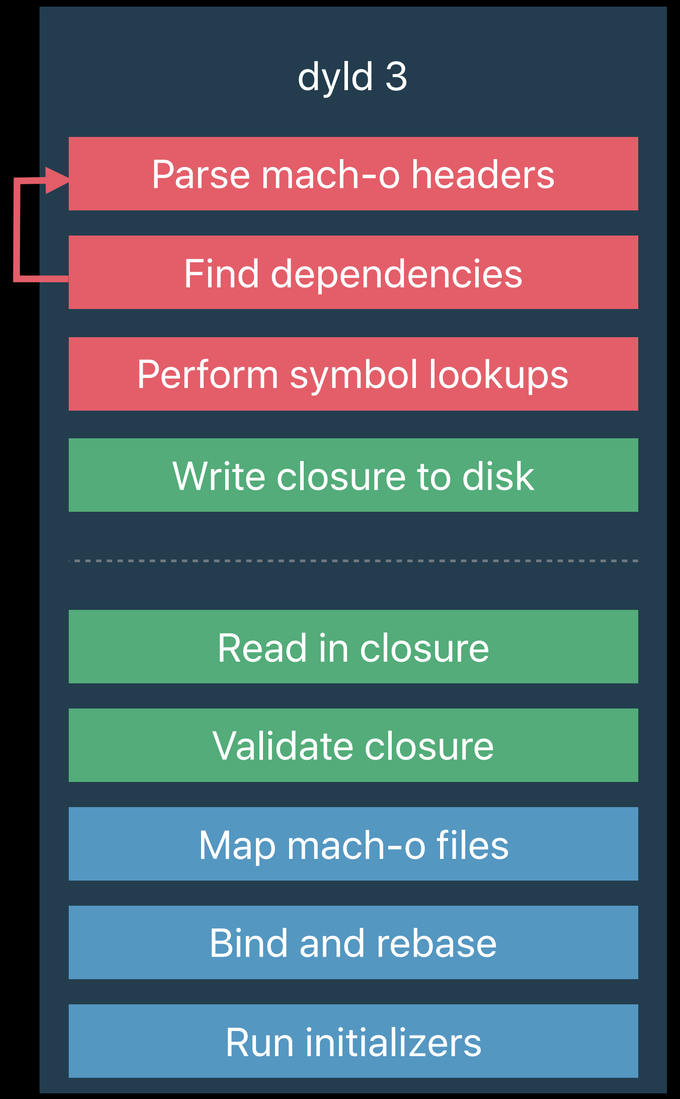
- An out of process MachO parser/compiler



dyld 3
Architecture

dyld 3 has 3 components

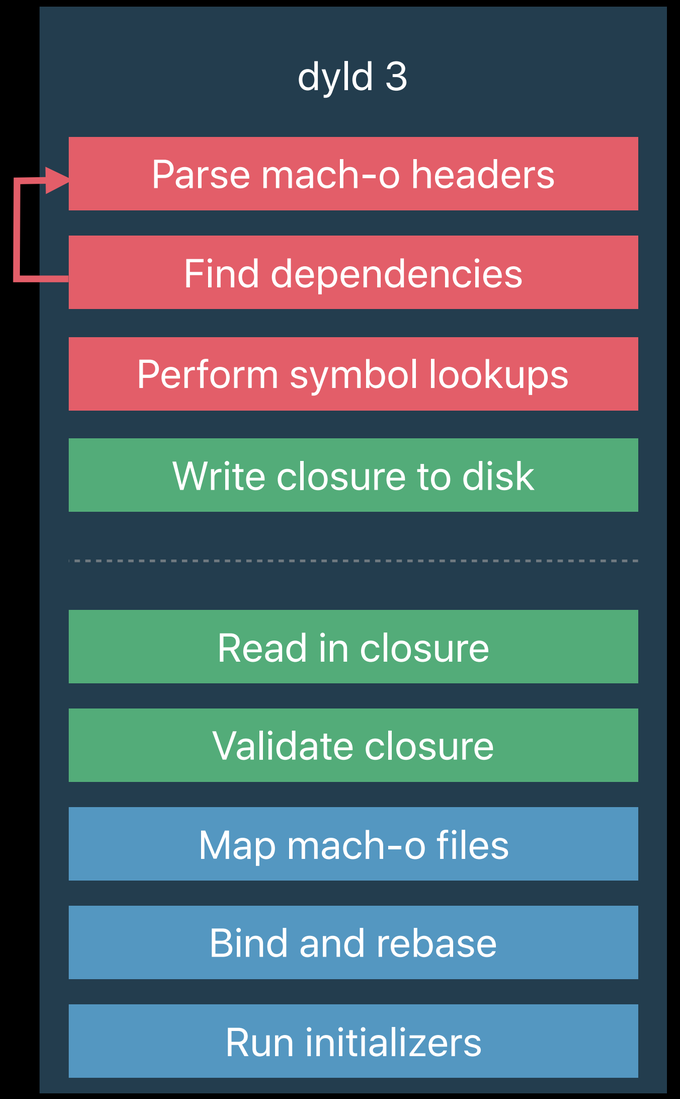
- An out of process MachO parser/compiler
- An in-process engine that runs launch closures



dyld 3
Architecture

dyld 3 has 3 components

- An out of process MachO parser/compiler
- An in-process engine that runs launch closures
- A launch closure caching service

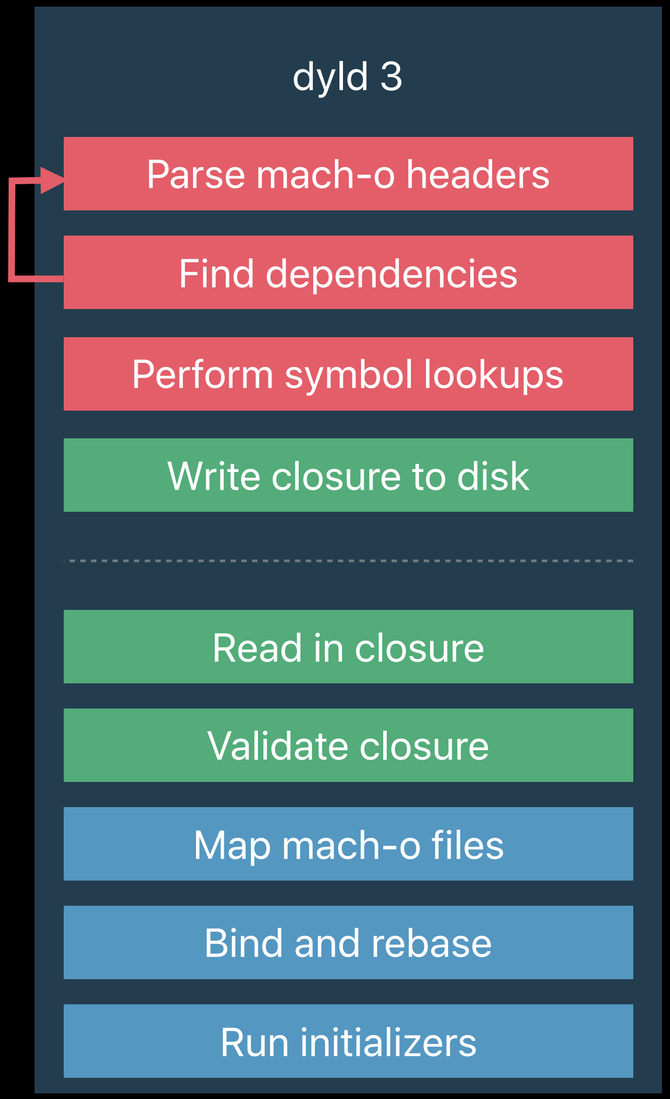


dyld 3
Architecture

dyld 3 has 3 components

- An out of process MachO parser/compiler
- An in-process engine that runs launch closures
- A launch closure caching service

Most launches use the cache and never invoke the out-of-process mach-o parser/compiler



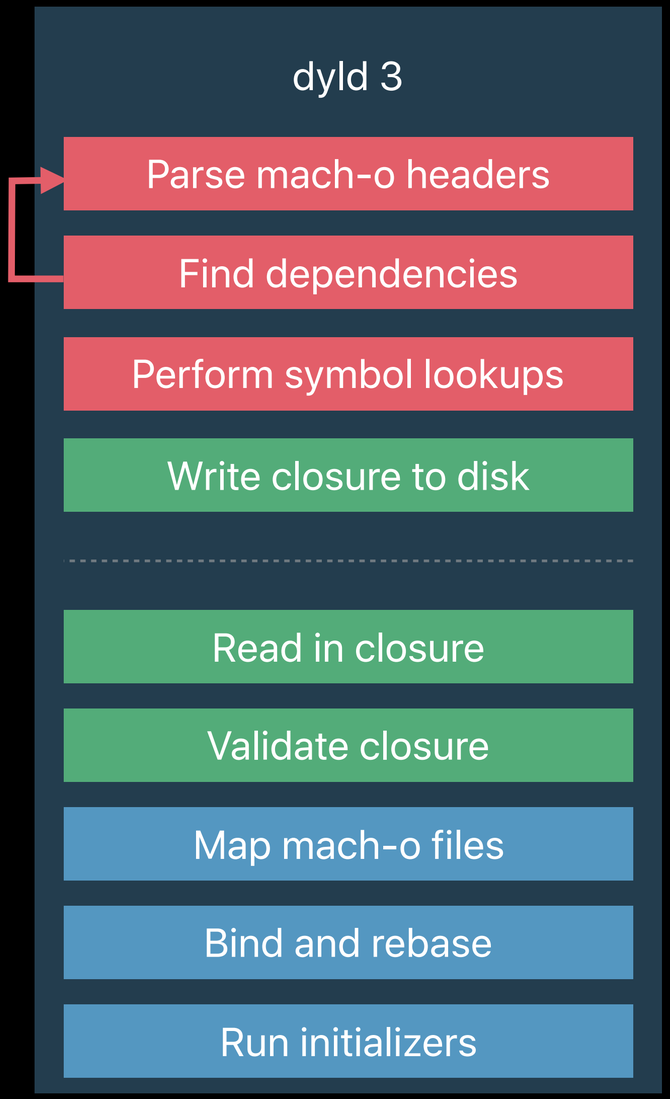
dyld 3
Architecture

dyld 3 has 3 components

- An out of process MachO parser/compiler
- An in-process engine that runs launch closures
- A launch closure caching service

Most launches use the cache and never invoke the out-of-process mach-o parser/compiler

- Launch closures are simpler than mach-o



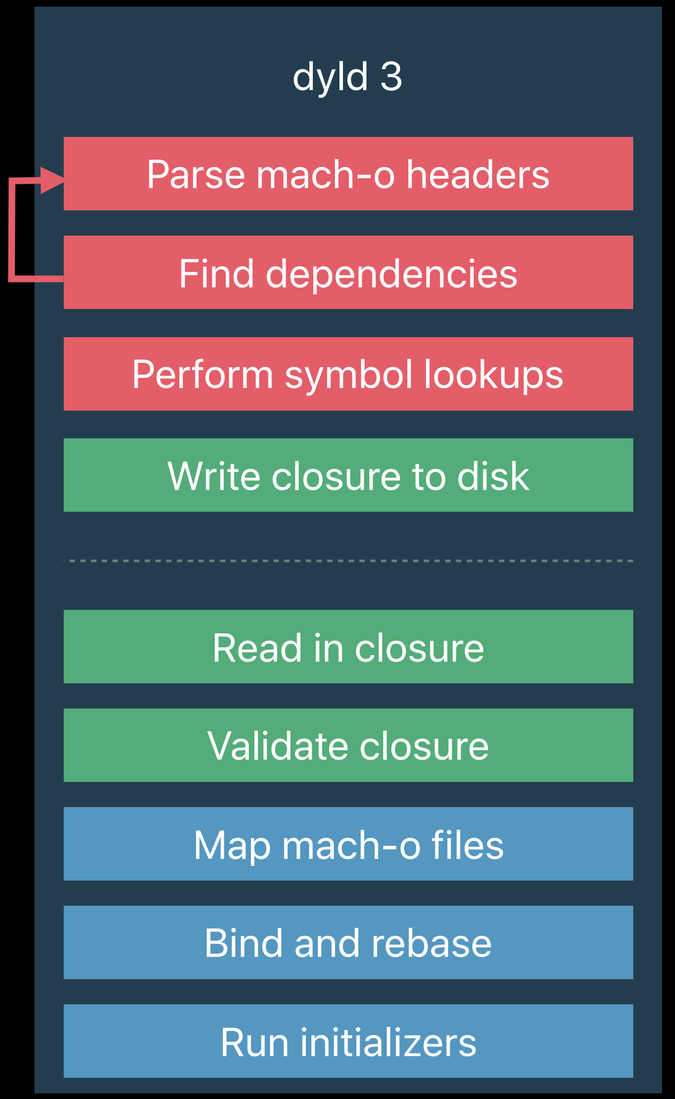
dyld 3
Architecture

dyld 3 has 3 components

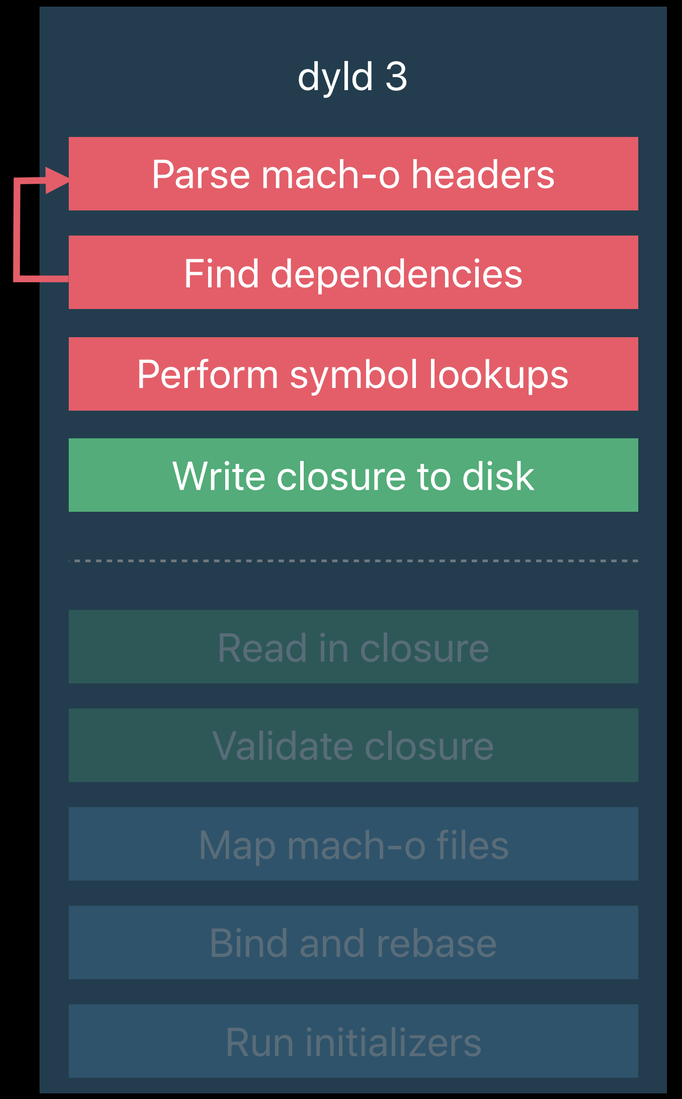
- An out of process MachO parser/compiler
- An in-process engine that runs launch closures
- A launch closure caching service

Most launches use the cache and never invoke the out-of-process mach-o parser/compiler

- Launch closures are simpler than mach-o
- Launch closures are built for speed

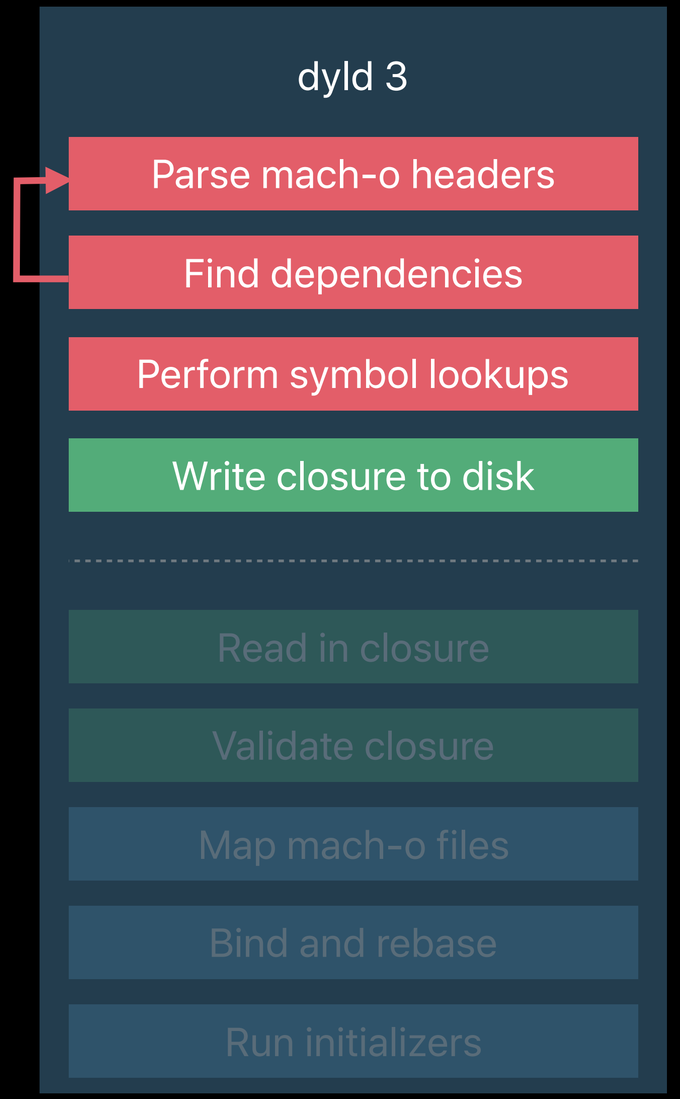


dyld 3
Architecture



dyld 3
Architecture

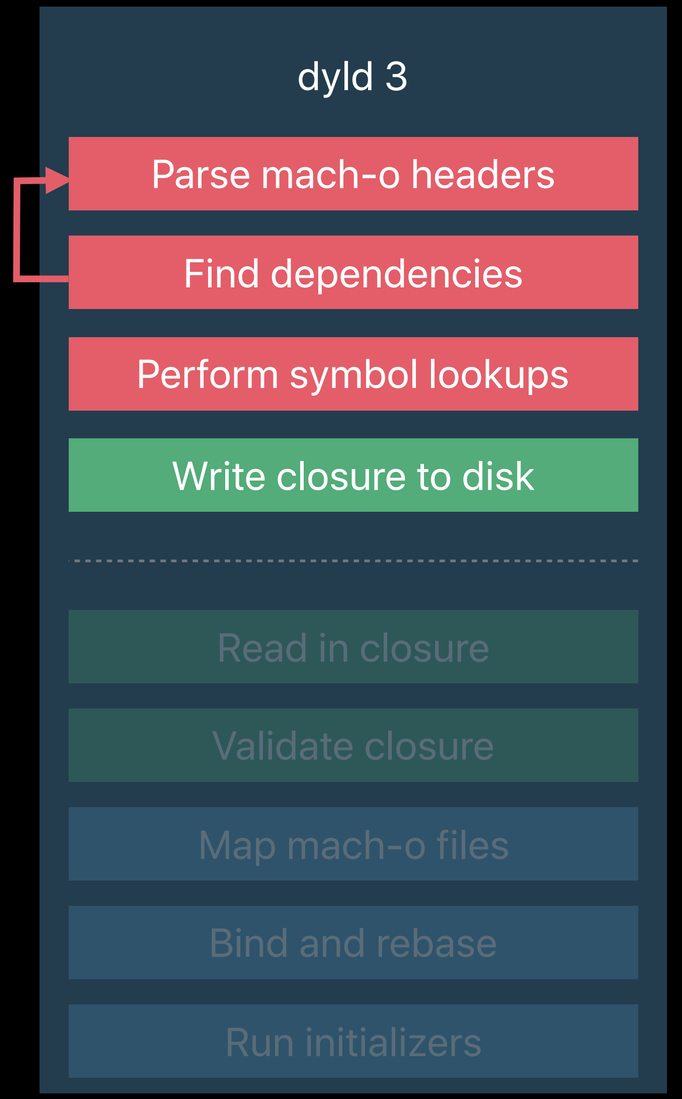
dyld 3 is an out-of-process mach-o parser



dyld 3
Architecture

dyld 3 is an out-of-process mach-o parser

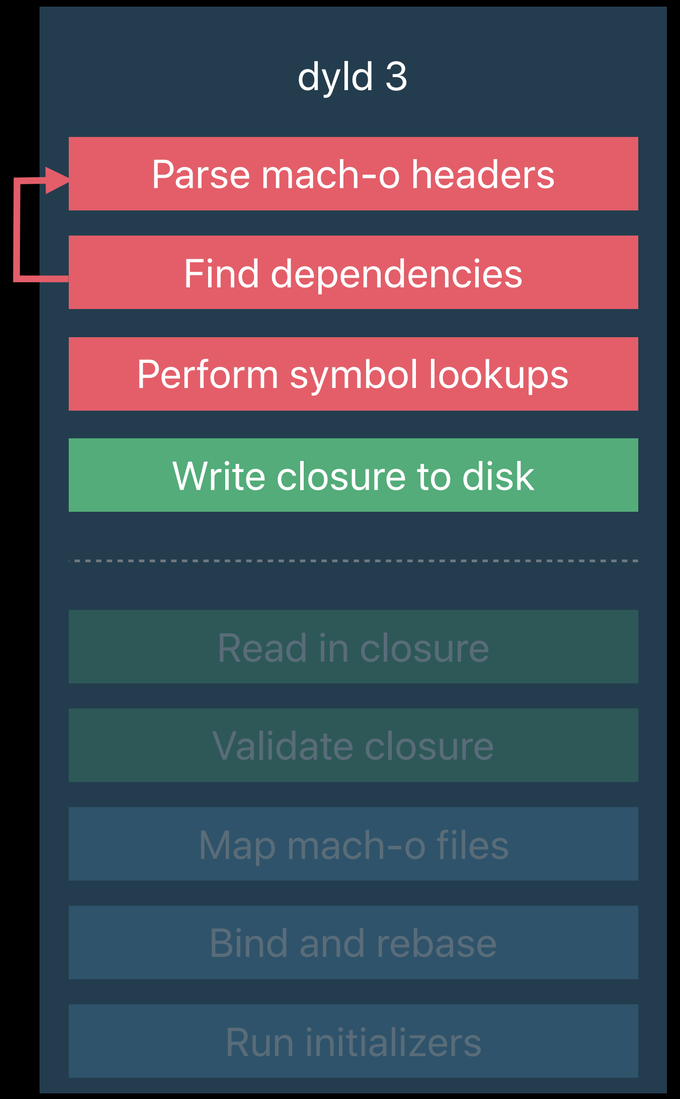
- Resolves all search paths, @rpaths, environment variables



dyld 3
Architecture

dyld 3 is an out-of-process mach-o parser

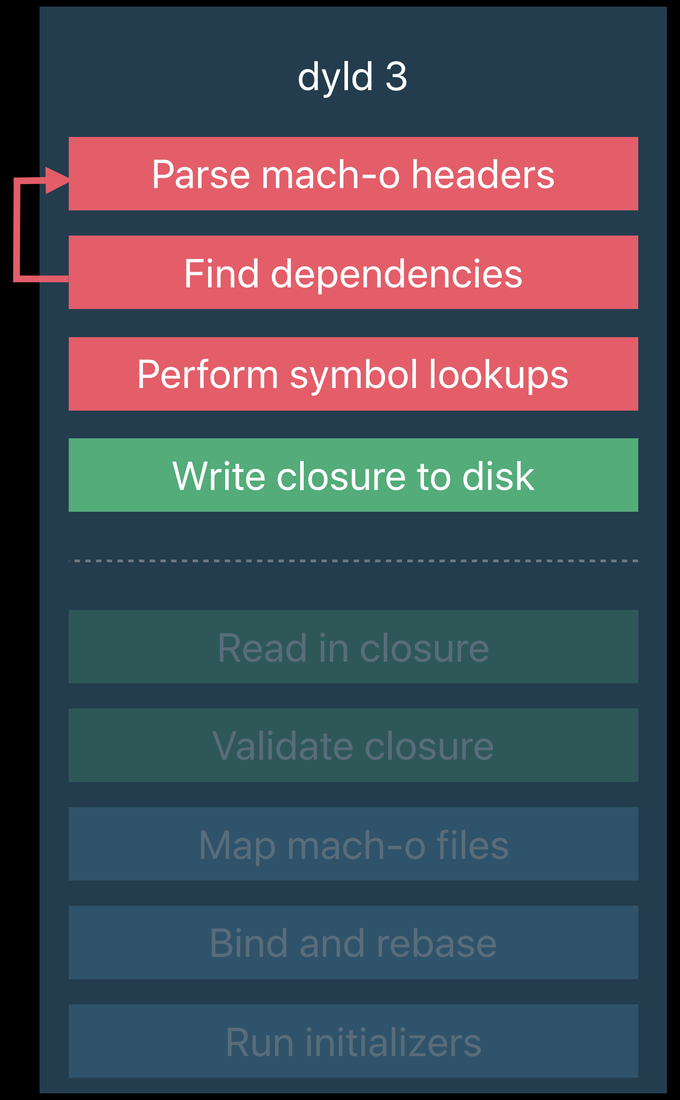
- Resolves all search paths, @rpaths, environment variables
- Parses the mach-o binaries



dyld 3
Architecture

dyld 3 is an out-of-process mach-o parser

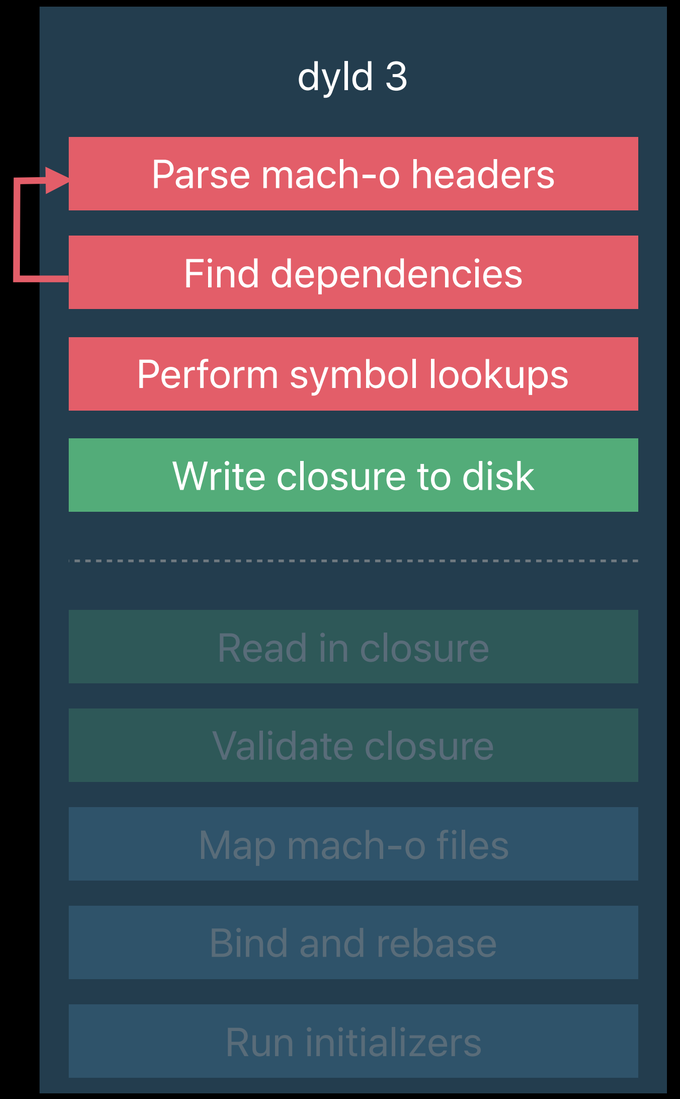
- Resolves all search paths, @rpaths, environment variables
- Parses the mach-o binaries
- Performs all symbol lookups



dyld 3
Architecture

dyld 3 is an out-of-process mach-o parser

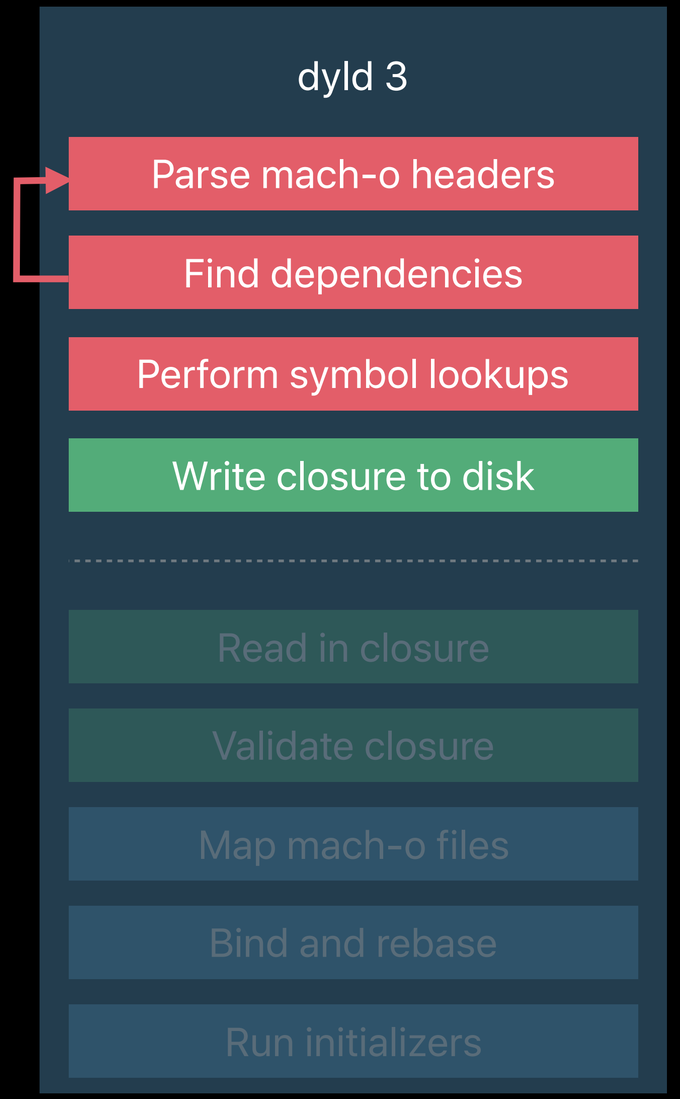
- Resolves all search paths, @rpaths, environment variables
- Parses the mach-o binaries
- Performs all symbol lookups
- Creates a launch closure with results



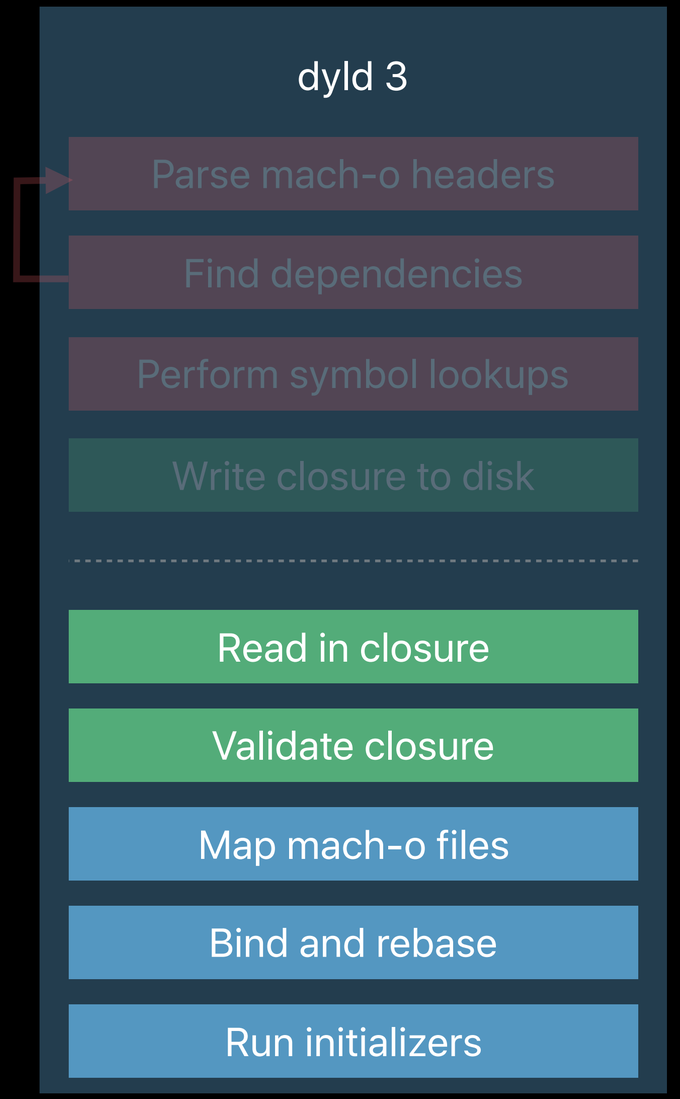
dyld 3
Architecture

dyld 3 is an out-of-process mach-o parser

- Resolves all search paths, @rpaths, environment variables
- Parses the mach-o binaries
- Performs all symbol lookups
- Creates a launch closure with results
- Is a normal daemon that can use normal testing infrastructure

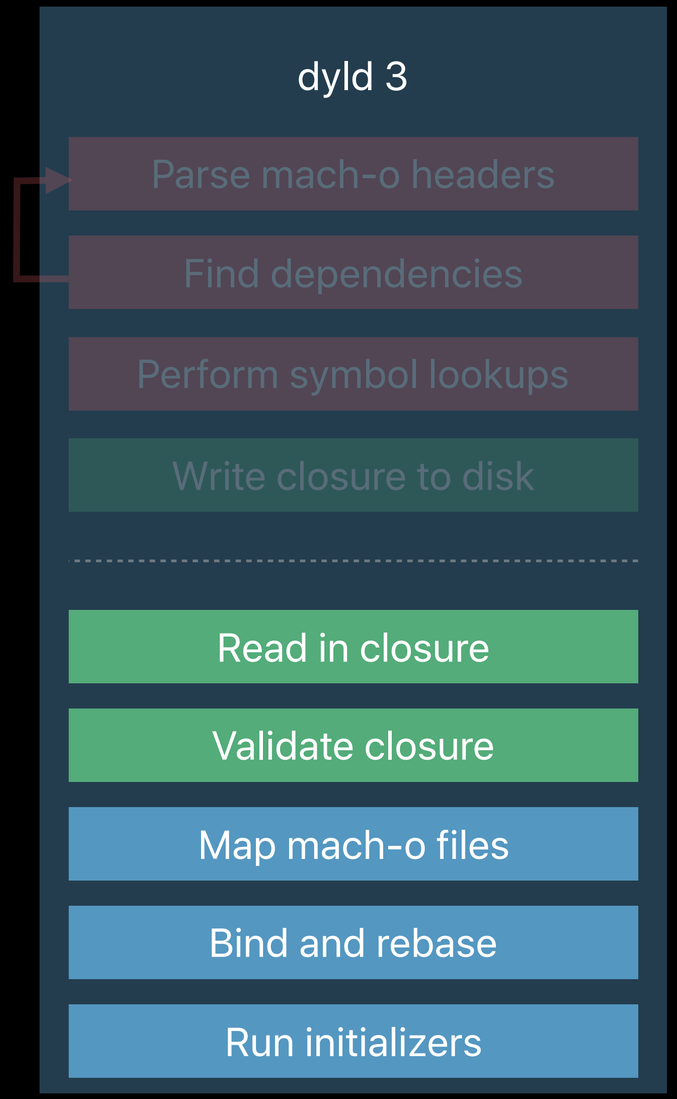


dyld 3
Architecture



dyld 3
Architecture

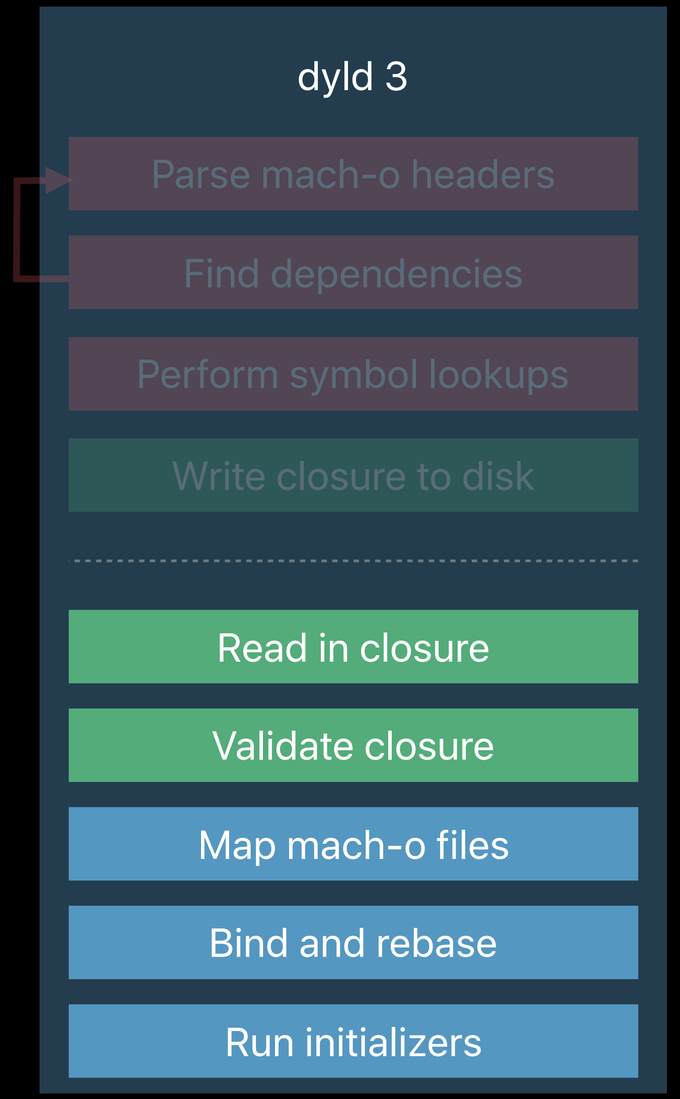
dyld 3 is a small in-process engine



dyld 3
Architecture

dyld 3 is a small in-process engine

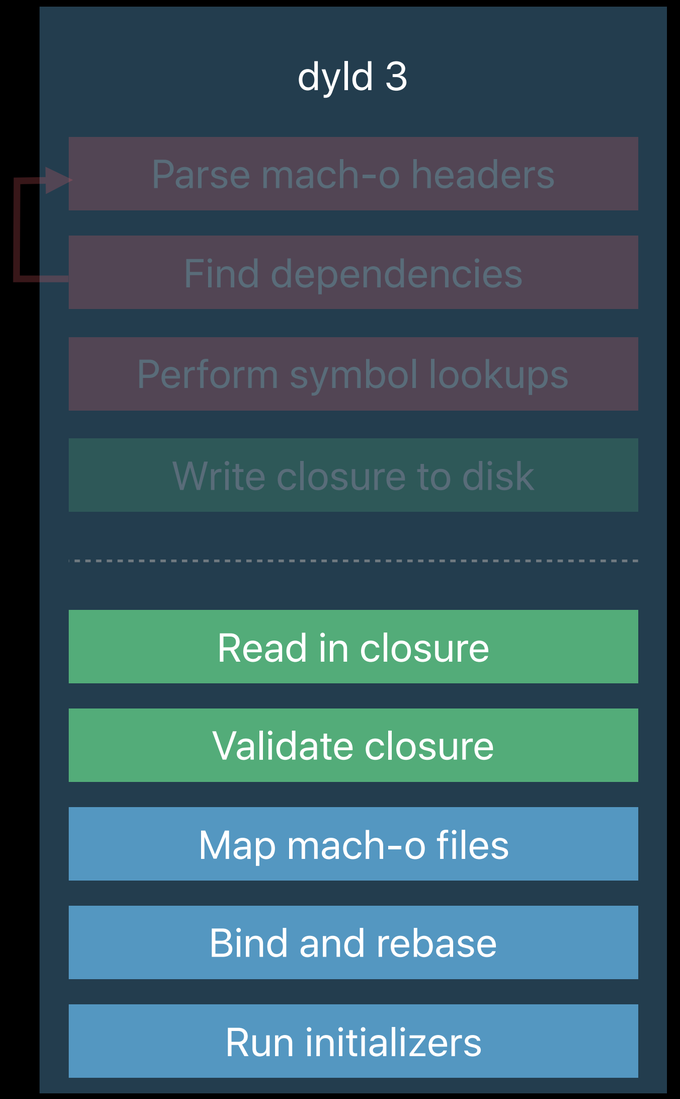
- Validates launch closure



dyld 3
Architecture

dyld 3 is a small in-process engine

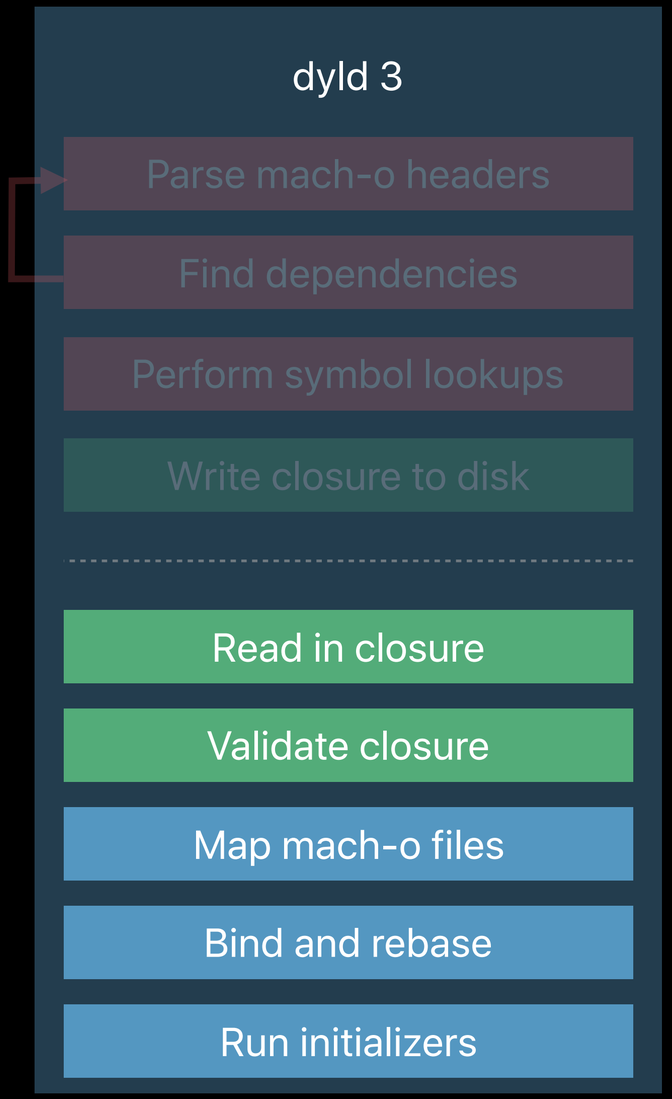
- Validates launch closure
- Maps in all dylibs



dyld 3
Architecture

dyld 3 is a small in-process engine

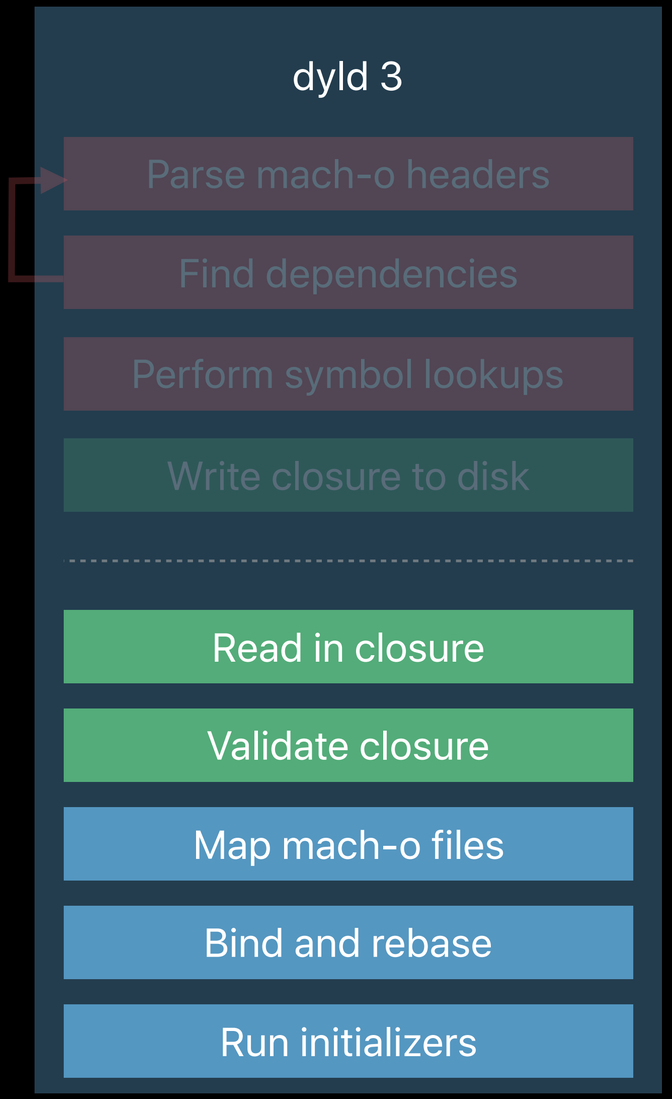
- Validates launch closure
- Maps in all dylibs
- Applies fixups



dyld 3
Architecture

dyld 3 is a small in-process engine

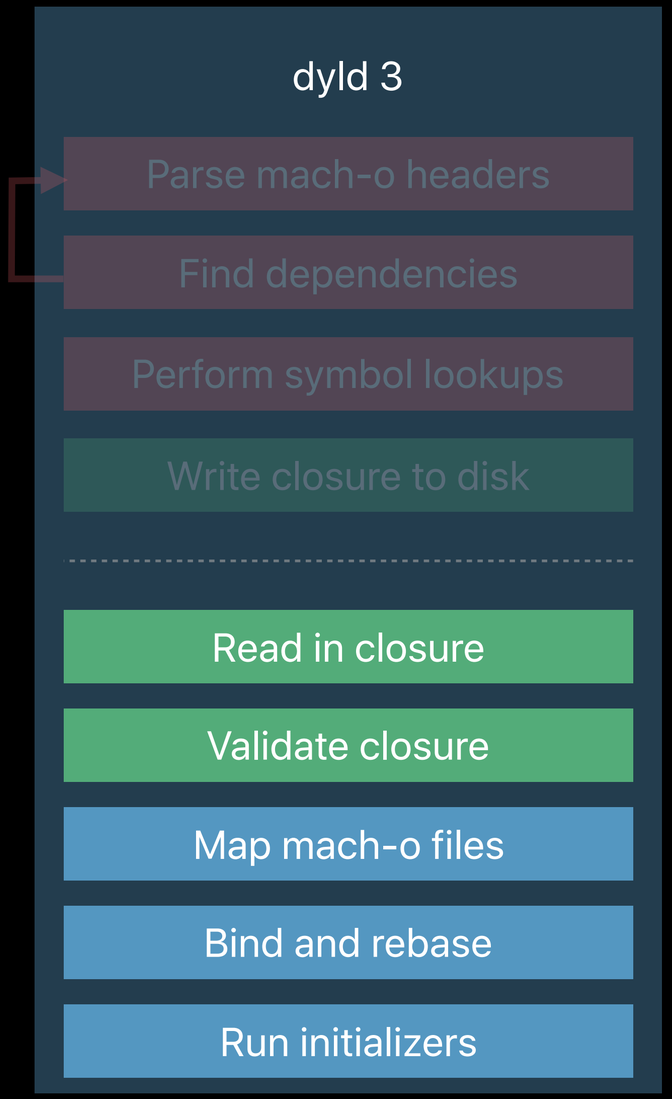
- Validates launch closure
- Maps in all dylibs
- Applies fixups
- Runs initializers



dyld 3
Architecture

dyld 3 is a small in-process engine

- Validates launch closure
- Maps in all dylibs
- Applies fixups
- Runs initializers
- Jumps to main()

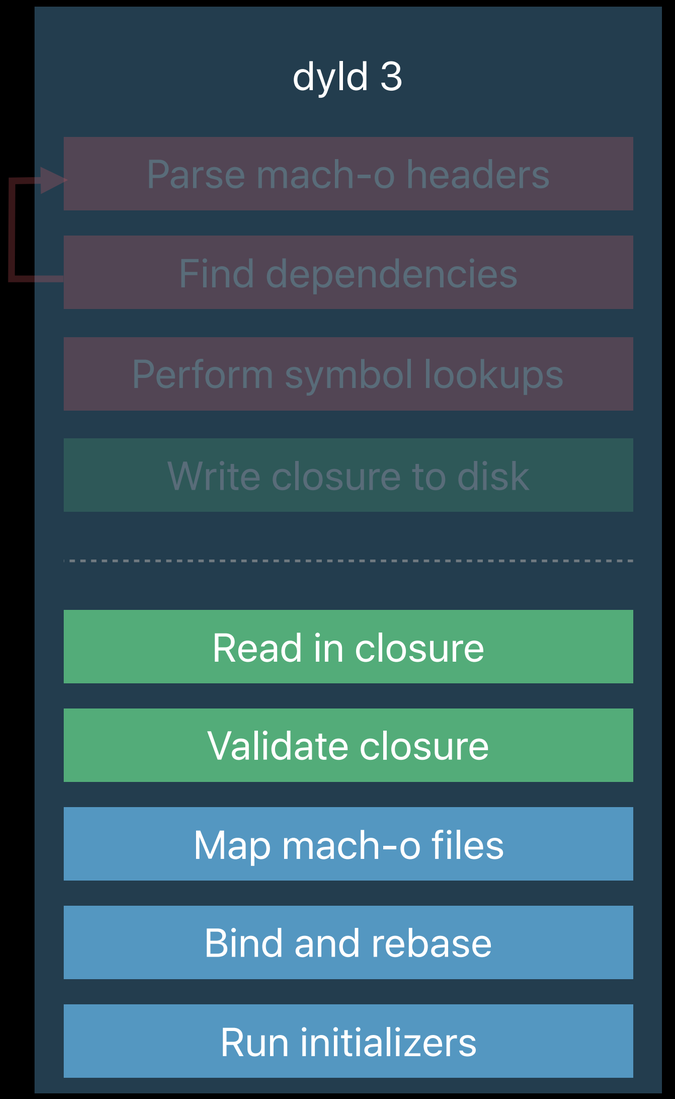


dyld 3
Architecture

dyld 3 is a small in-process engine

- Validates launch closure
- Maps in all dylibs
- Applies fixups
- Runs initializers
- Jumps to main()

Never needs to parse mach-o headers or access the symbol tables



dyld 3

Architecture

dyld 3

Architecture

dyld 3 is a launch closure cache

dyld 3

Architecture

dyld 3 is a launch closure cache

- System app launch closures built into shared cache

dyld 3

Architecture

dyld 3 is a launch closure cache

- System app launch closures built into shared cache
- Third-party app launch closures built during install

dyld 3

Architecture

dyld 3 is a launch closure cache

- System app launch closures built into shared cache
- Third-party app launch closures built during install
  - Rebuilt during software update

dyld 3

Architecture

dyld 3 is a launch closure cache

- System app launch closures built into shared cache
- Third-party app launch closures built during install
  - Rebuilt during software update
- On macOS the in process engine can call out to a daemon if necessary

dyld 3

Architecture

dyld 3 is a launch closure cache

- System app launch closures built into shared cache
- Third-party app launch closures built during install
  - Rebuilt during software update
- On macOS the in process engine can call out to a daemon if necessary
  - Not necessary on other Apple OS platforms

Preparing for dyld 3

Potential issues

Preparing for dyld 3

Potential issues

Fully compatible with dyld 2.x

Preparing for dyld 3

Potential issues

Fully compatible with dyld 2.x

- Some existing APIs disable dyld 3’s optimizations or require slow fallback paths

Preparing for dyld 3

Potential issues

Fully compatible with dyld 2.x

- Some existing APIs disable dyld 3’s optimizations or require slow fallback paths
- Some existing optimizations done for dyld 2.x no longer have any impact

Preparing for dyld 3

Potential issues

Fully compatible with dyld 2.x

- Some existing APIs disable dyld 3's optimizations or require slow fallback paths
- Some existing optimizations done for dyld 2.x no longer have any impact

Stricter linking semantics

Preparing for dyld 3

Potential issues

Fully compatible with dyld 2.x

- Some existing APIs disable dyld 3's optimizations or require slow fallback paths
- Some existing optimizations done for dyld 2.x no longer have any impact

Stricter linking semantics

- Workarounds for old binaries

Preparing for dyld 3

Potential issues

Fully compatible with dyld 2.x

- Some existing APIs disable dyld 3’s optimizations or require slow fallback paths
- Some existing optimizations done for dyld 2.x no longer have any impact

Stricter linking semantics

- Workarounds for old binaries
- New binaries will cause linker errors

Preparing for dyld 3

Unaligned pointers in __DATA

Preparing for dyld 3

Unaligned pointers in __DATA

When you have a global struct it is placed in the data segment

Preparing for dyld 3

Unaligned pointers in __DATA

When you have a global struct it is placed in the data segment

- Unaligned pointers in the struct will be embedded in the __DATA segment

Preparing for dyld 3

Unaligned pointers in __DATA

When you have a global struct it is placed in the data segment

- Unaligned pointers in the struct will be embedded in the __DATA segment

Fixing up unaligned pointers is more complex

Preparing for dyld 3

Unaligned pointers in __DATA

When you have a global struct it is placed in the data segment

- Unaligned pointers in the struct will be embedded in the __DATA segment

Fixing up unaligned pointers is more complex

- Can span multiple pages

Preparing for dyld 3

Unaligned pointers in __DATA

When you have a global struct it is placed in the data segment

- Unaligned pointers in the struct will be embedded in the __DATA segment

Fixing up unaligned pointers is more complex

- Can span multiple pages
- Can have atomicity issues

Preparing for dyld 3

Unaligned pointers in __DATA

When you have a global struct it is placed in the data segment

- Unaligned pointers in the struct will be embedded in the __DATA segment

Fixing up unaligned pointers is more complex

- Can span multiple pages
- Can have atomicity issues

The static linker already emits a warning

Preparing for dyld 3

Unaligned pointers in __DATA

When you have a global struct it is placed in the data segment

- Unaligned pointers in the struct will be embedded in the __DATA segment

Fixing up unaligned pointers is more complex

- Can span multiple pages
- Can have atomicity issues

The static linker already emits a warning

```
ld: warning: pointer not aligned at address 0x10056E59C
```

```
struct ListHead {
};

#pragma pack(1) // Changes default alignment globally
struct List {
    uint32_t count;  // 4 bytes @ 0x0
    struct ListElement *head; // 8 bytes @ 0x4: MISALIGNED!!
} __attribute__((__packed__, aligned(1))); // Changes alignment for this struct

static struct ListElement sHead;
struct List gList = {0, &sHead}; //pointer not aligned at address 0x100001004 (_gList + 4 from
...)
```

```
struct ListHead {
};

#pragma pack(1) // Changes default alignment globally
struct List {
    uint32_t count;  // 4 bytes @ 0x0
    struct ListElement *head; // 8 bytes @ 0x4: MISALIGNED!!
} __attribute__((__packed__, aligned(1))); // Changes alignment for this struct

static struct ListElement sHead;
struct List gList = {0, &sHead}; //pointer not aligned at address 0x100001004 (_gList + 4 from
...)
```

```
struct ListHead {
};

#pragma pack(1) // Changes default alignment globally
struct List {
    uint32_t count;  // 4 bytes @ 0x0
    struct ListElement *head; // 8 bytes @ 0x4: MISALIGNED!!
} __attribute__((__packed__, aligned(1))); // Changes alignment for this struct

static struct ListElement sHead;
struct List gList = {0, &sHead}; //pointer not aligned at address 0x100001004 (_gList + 4 from
...)
```

```
struct ListHead {
};

#pragma pack(1) // Changes default alignment globally
struct List {
    uint32_t count;  // 4 bytes @ 0x0
    struct ListElement *head; // 8 bytes @ 0x4: MISALIGNED!!
} __attribute__((__packed__, aligned(1))); // Changes alignment for this struct

static struct ListElement sHead;
struct List gList = {0, &sHead}; //pointer not aligned at address 0x100001004 (_gList + 4 from
...)
```

Preparing for dyld 3

Eager symbol resolution

Preparing for dyld 3

Eager symbol resolution

dyld 2 performs lazy symbol resolution

Preparing for dyld 3

Eager symbol resolution

dyld 2 performs lazy symbol resolution

- Symbol lookups are too expensive to do them up front

Preparing for dyld 3

Eager symbol resolution

dyld 2 performs lazy symbol resolution

- Symbol lookups are too expensive to do them up front
- Each symbol is looked up the first time you call it

Preparing for dyld 3

Eager symbol resolution

dyld 2 performs lazy symbol resolution

- Symbol lookups are too expensive to do them up front
- Each symbol is looked up the first time you call it
- Missing symbols cause a crash the first time they are called

Preparing for dyld 3

Eager symbol resolution

dyld 2 performs lazy symbol resolution

- Symbol lookups are too expensive to do them up front
- Each symbol is looked up the first time you call it
- Missing symbols cause a crash the first time they are called

dyld 3 performs eager symbol resolutions

Preparing for dyld 3

Eager symbol resolution

dyld 2 performs lazy symbol resolution

- Symbol lookups are too expensive to do them up front
- Each symbol is looked up the first time you call it
- Missing symbols cause a crash the first time they are called

dyld 3 performs eager symbol resolutions

- Since all symbol lookups are cached it is very fast

Preparing for dyld 3

Eager symbol resolution

dyld 2 performs lazy symbol resolution

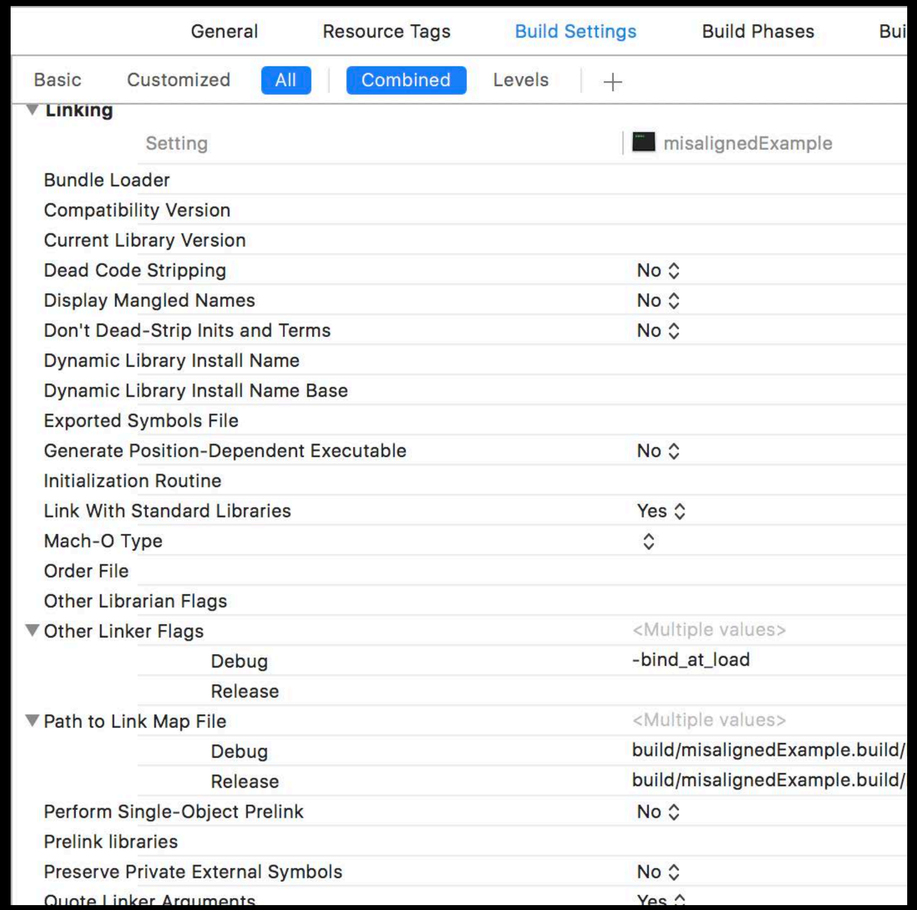
- Symbol lookups are too expensive to do them up front
- Each symbol is looked up the first time you call it
- Missing symbols cause a crash the first time they are called

dyld 3 performs eager symbol resolutions

- Since all symbol lookups are cached it is very fast
- Makes it possible to check if all symbols are present

Preparing for dyld 3

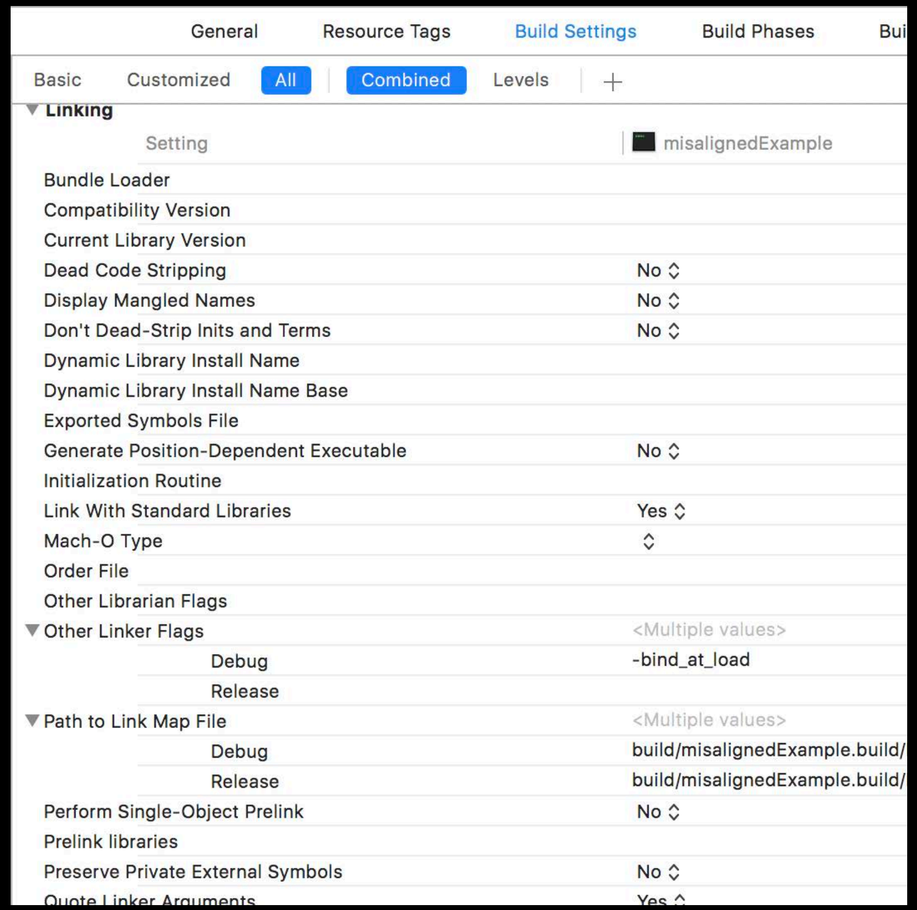
Eager symbol resolution



Preparing for dyld 3

Eager symbol resolution

Apps built against current SDKs will run with unknown symbols

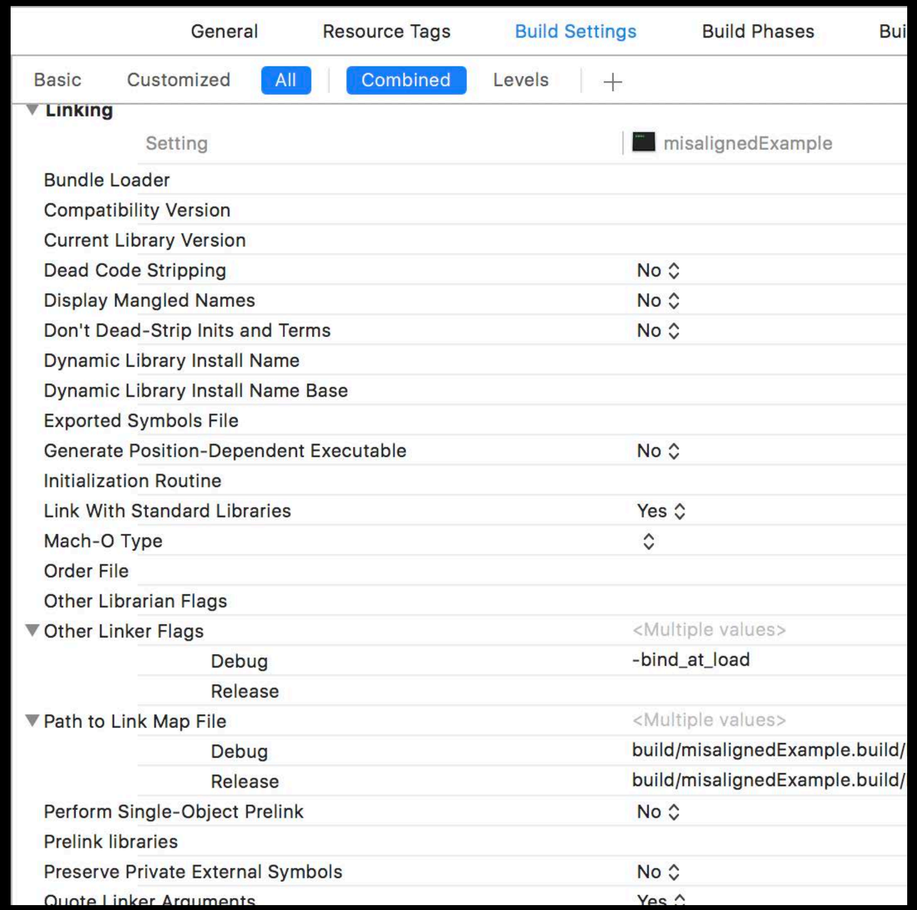


Preparing for dyld 3

Eager symbol resolution

Apps built against current SDKs will run with unknown symbols

- Identical behavior to dyld 2, on first call it will crash



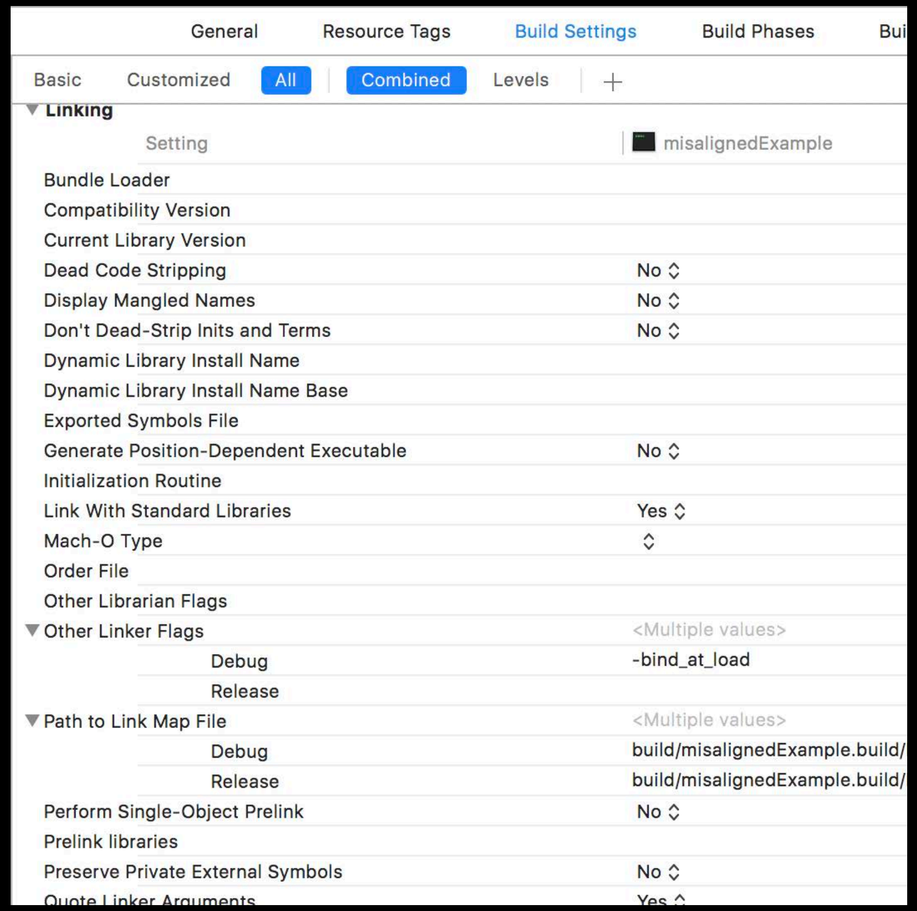
Preparing for dyld 3

Eager symbol resolution

Apps built against current SDKs will run with unknown symbols

- Identical behavior to dyld 2, on first call it will crash

Apps built against future SDKs will fail to launch with unknown symbols



Preparing for dyld 3

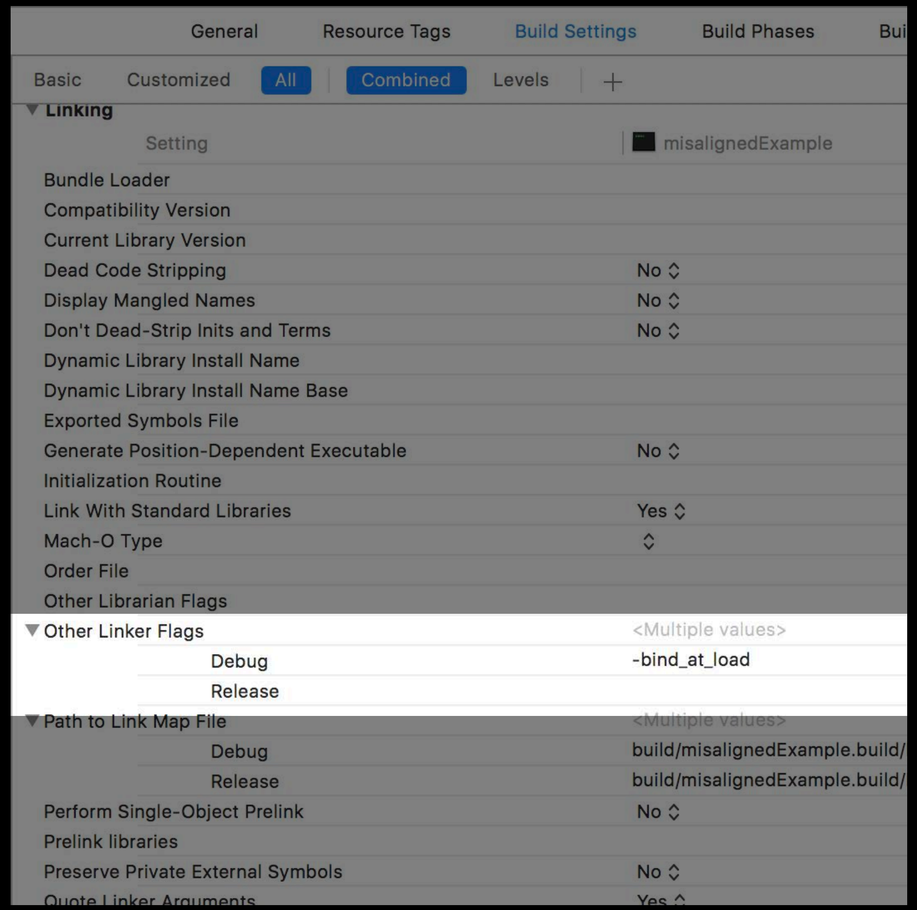
Eager symbol resolution

Apps built against current SDKs will run with unknown symbols

- Identical behavior to dyld 2, on first call it will crash

Apps built against future SDKs will fail to launch with unknown symbols

- Can simulate behavior today with -bind_at_load linker flag



Preparing for dyld 3

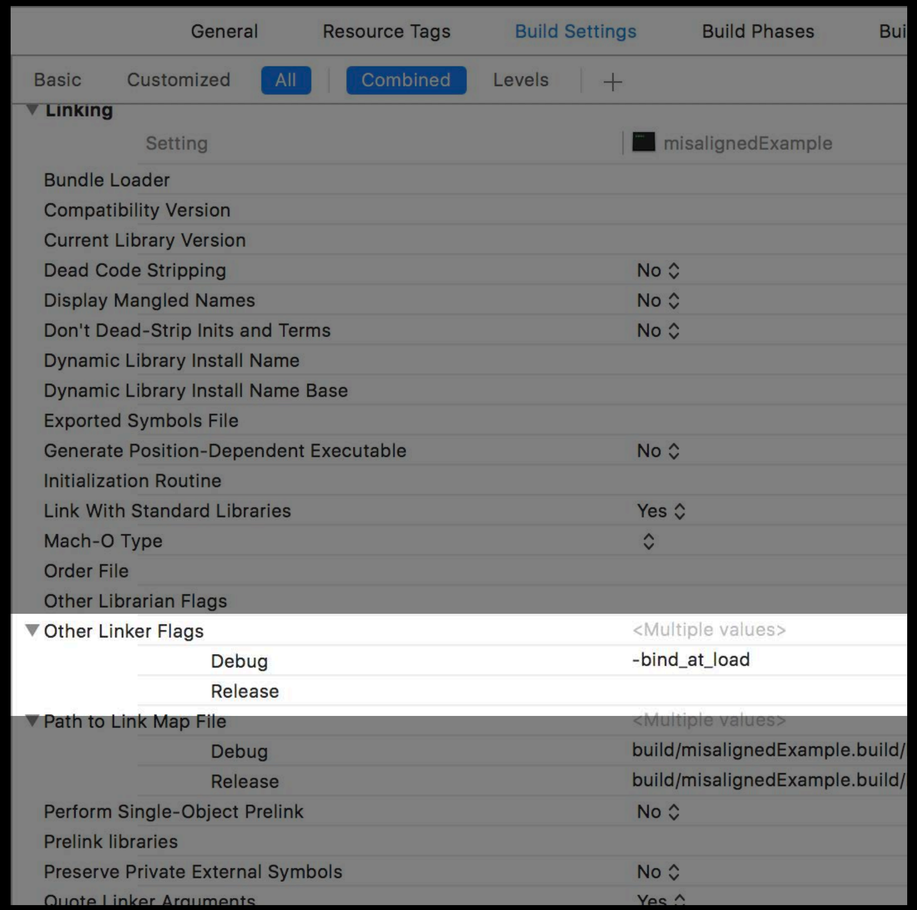
Eager symbol resolution

Apps built against current SDKs will run with unknown symbols

- Identical behavior to dyld 2, on first call it will crash

Apps built against future SDKs will fail to launch with unknown symbols

- Can simulate behavior today with -bind_at_load linker flag
- Only use on test builds, not release



Preparing for dyld 3

dlopen()/dlsym()/dladdr()

Preparing for dyld 3

dlopen()/dlsym()/dladdr()

Still have problematic semantics

Preparing for dyld 3

dlopen()/dlsym()/dladdr()

Still have problematic semantics

- Still necessary in some cases

Preparing for dyld 3

dlopen()/dlsym()/dladdr()

Still have problematic semantics

- Still necessary in some cases

Symbols found with dlsym() must be found at runtime

Preparing for dyld 3

dlopen()/dlsym()/dladdr()

Still have problematic semantics

- Still necessary in some cases

Symbols found with dlsym() must be found at runtime

- Cannot be pre-linked by dyld 3

Preparing for dyld 3

dlopen()/dlsym()/dladdr()

Still have problematic semantics

- Still necessary in some cases

Symbols found with dlsym() must be found at runtime

- Cannot be pre-linked by dyld 3

We are working on better alternatives

Preparing for dyld 3

dlopen()/dlsym()/dladdr()

Still have problematic semantics

- Still necessary in some cases

Symbols found with dlsym() must be found at runtime

- Cannot be pre-linked by dyld 3

We are working on better alternatives

- Want to hear about your use cases

Preparing for dyld 3

dlopen()/dlsym()/dladdr()

Still have problematic semantics

- Still necessary in some cases

Symbols found with dlsym() must be found at runtime

- Cannot be pre-linked by dyld 3

We are working on better alternatives

- Want to hear about your use cases
- Not going away, but may be slower in dyld 3

Preparing for dyld 3

dlclose()

Preparing for dyld 3

dlclose()

Misnomer

Preparing for dyld 3

dlclose()

Misnomer

- Decrements a refcount, does not necessarily close the dylib

Preparing for dyld 3

dlclose()

Misnomer

- Decrements a refcount, does not necessarily close the dylib
- Not appropriate for resource management

Preparing for dyld 3

dlclose()

Misnomer

- Decrements a refcount, does not necessarily close the dylib
- Not appropriate for resource management

Features that prevent a dylib from unloading

Preparing for dyld 3

dlclose()

Misnomer

- Decrements a refcount, does not necessarily close the dylib
- Not appropriate for resource management

Features that prevent a dylib from unloading

- Objective-C classes

Preparing for dyld 3

dlclose()

Misnomer

- Decrements a refcount, does not necessarily close the dylib
- Not appropriate for resource management

Features that prevent a dylib from unloading

- Objective-C classes
- Swift classes

Preparing for dyld 3

dlclose()

Misnomer

- Decrements a refcount, does not necessarily close the dylib
- Not appropriate for resource management

Features that prevent a dylib from unloading

- Objective-C classes
- Swift classes
- C __thread and C++ thread_local variables

Preparing for dyld 3

dlclose()

Misnomer

- Decrements a refcount, does not necessarily close the dylib
- Not appropriate for resource management

Features that prevent a dylib from unloading

- Objective-C classes
- Swift classes
- C __thread and C++ thread_local variables

Considering making dlclose() a no-op everywhere except macOS

Preparing for dyld 3

all_image_infos

Preparing for dyld 3

all_image_infos

Interface for introspecting dylibs in a process

Preparing for dyld 3

all_image_infos

Interface for introspecting dylibs in a process

- Struct in memory

Preparing for dyld 3

all_image_infos

Interface for introspecting dylibs in a process

- Struct in memory
- Wastes a lot of memory

Preparing for dyld 3

all_image_infos

Interface for introspecting dylibs in a process

- Struct in memory
- Wastes a lot of memory
- Going away in future releases

Preparing for dyld 3

all_image_infos

Interface for introspecting dylibs in a process

- Struct in memory
- Wastes a lot of memory
- Going away in future releases
- We will be providing replacement APIs

Preparing for dyld 3

all_image_infos

Interface for introspecting dylibs in a process

- Struct in memory
- Wastes a lot of memory
- Going away in future releases
- We will be providing replacement APIs
- Please let us know how you use it

Preparing for dyld 3

Best Practices

Preparing for dyld 3

Best Practices

Make sure your app launches when built with `-bind_at_load` added to LD_FLAGS

Preparing for dyld 3

Best Practices

Make sure your app launches when built with `-bind_at_load` added to LD_FLAGS

- Debug builds only

Preparing for dyld 3

Best Practices

Make sure your app launches when built with `-bind_at_load` added to LD_FLAGS

- Debug builds only

Fix any unaligned pointers in your app's __DATA segment

Preparing for dyld 3

Best Practices

Make sure your app launches when built with `-bind_at_load` added to LD_FLAGS

- Debug builds only

Fix any unaligned pointers in your app's __DATA segment

```
ld: warning: pointer not aligned at address 0x100001004
```

Preparing for dyld 3

Best Practices

Make sure your app launches when built with `-bind_at_load` added to LD_FLAGS

- Debug builds only

Fix any unaligned pointers in your app's __DATA segment

```
ld: warning: pointer not aligned at address 0x100001004
```

Make sure you are not depending on terminators running when you call dlclose()

Preparing for dyld 3

Best Practices

Make sure your app launches when built with `-bind_at_load` added to LD_FLAGS

- Debug builds only

Fix any unaligned pointers in your app's __DATA segment

```
ld: warning: pointer not aligned at address 0x100001004
```

Make sure you are not depending on terminators running when you call dlclose()

Let us know why you are using dlopen()/dlsym()/dladdr()/all_image_infos

Preparing for dyld 3

Best Practices

Make sure your app launches when built with `-bind_at_load` added to LD_FLAGS

- Debug builds only

Fix any unaligned pointers in your app's __DATA segment

```
ld: warning: pointer not aligned at address 0x100001004
```

Make sure you are not depending on terminators running when you call dlclose()

Let us know why you are using dlopen()/dlsym()/dladdr()/all_image_infos

- File bug reports with "DYLD USAGE:" in their titles

More Information

https://developer.apple.com/wwdc17/413

Related Sessions

Optimizing App Startup Time	WWDC 2016

Labs

Optimizing App Startup Time Lab	Technology Lab E	Fri 11:00AM–12:30PM


WWDC17