Core Bluetooth

Session 703

Jason Conn
Code Monkey & Radio Sponge

Brian Tucker
Bluetooth SIG Grand Wizard

Renaud Lienhart
Keeper of the Code &
General Curmudgeon

BLE State of the Union

Evolution of Core Bluetooth

Core Bluetooth in iOS 7

Code Demo

Tips and Best Practices

BLE State of the Union

Evolution of Core Bluetooth

Core Bluetooth in iOS 7

Code Demo

Tips and Best Practices

BLE State of the Union

Evolution of Core Bluetooth

Core Bluetooth in iOS 7

Code Demo

Tips and Best Practices

BLE State of the Union

Evolution of Core Bluetooth

Core Bluetooth in iOS 7

Code Demo

Tips and Best Practices

BLE State of the Union

Evolution of Core Bluetooth

Core Bluetooth in iOS 7

Code Demo

Tips and Best Practices

BLE State of the Union

Evolution of Core Bluetooth

Core Bluetooth in iOS 7

Code Demo

Tips and Best Practices

BLE: State of the Union

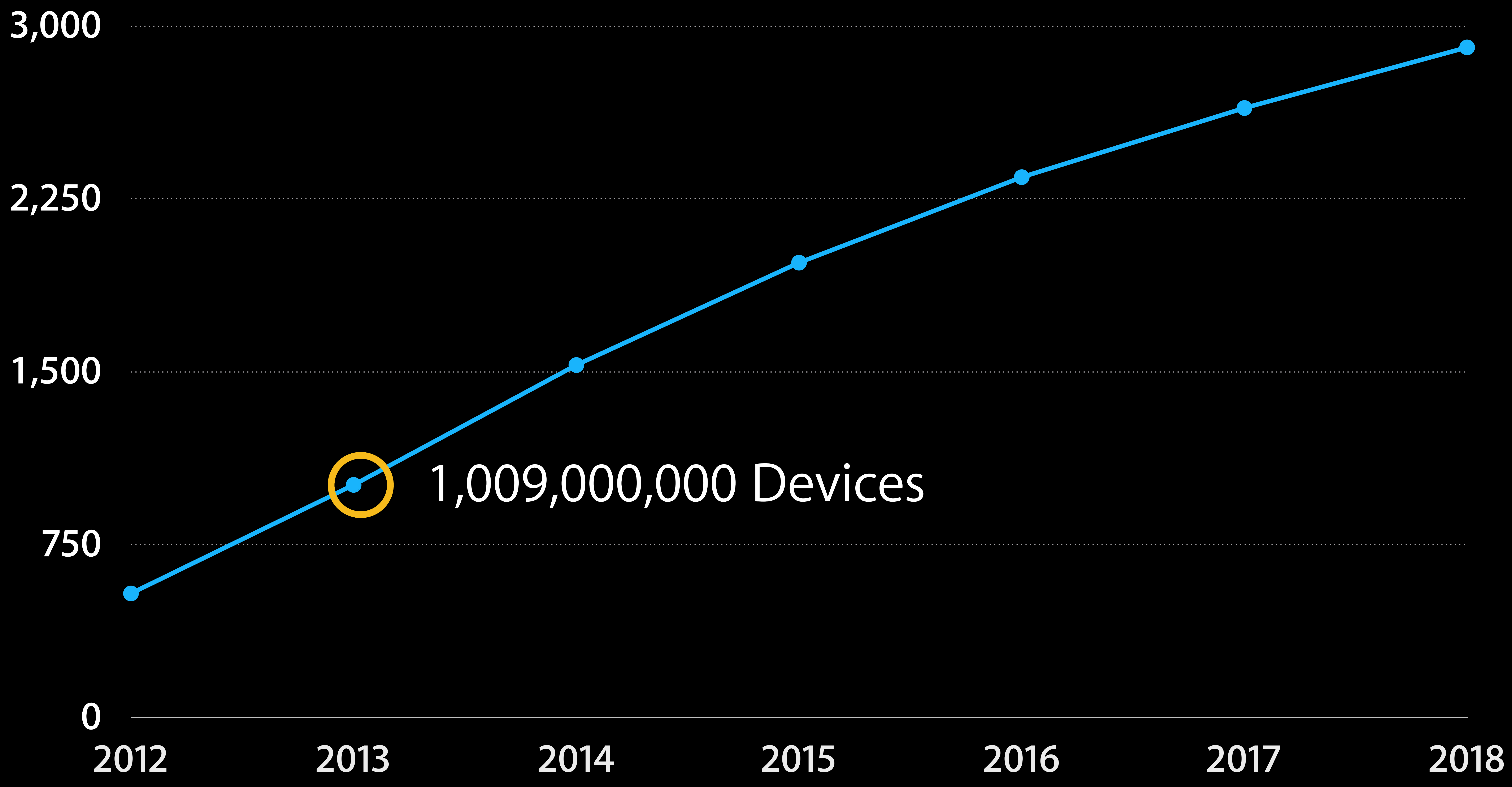
Brian Tucker
Bluetooth SIG Grand Wizard

1 Billion+

Projected BLE Accessories Shipped

Source ABI Research 2013

Projected BLE Accessories Shipped



Source ABI Research 2013

Health Care

Sports/Fitness

Security

Automation

Entertainment

Toys

Pay Systems

Time Services

Proximity

Evolution of Core Bluetooth

Renaud Lienhart
Keeper of the Code & General Curmudgeon

iOS 5

Observer, Central, Client

- CBCentralManager
  - Discover peripherals
  - Connect
- CBPeripheral
  - Access remote services

iOS 6

Broadcaster, Peripheral, Server

- CBPeripheralManager
  - Host services
  - Advertise information
  - Field CBCentral requests
- Peripheral database caching

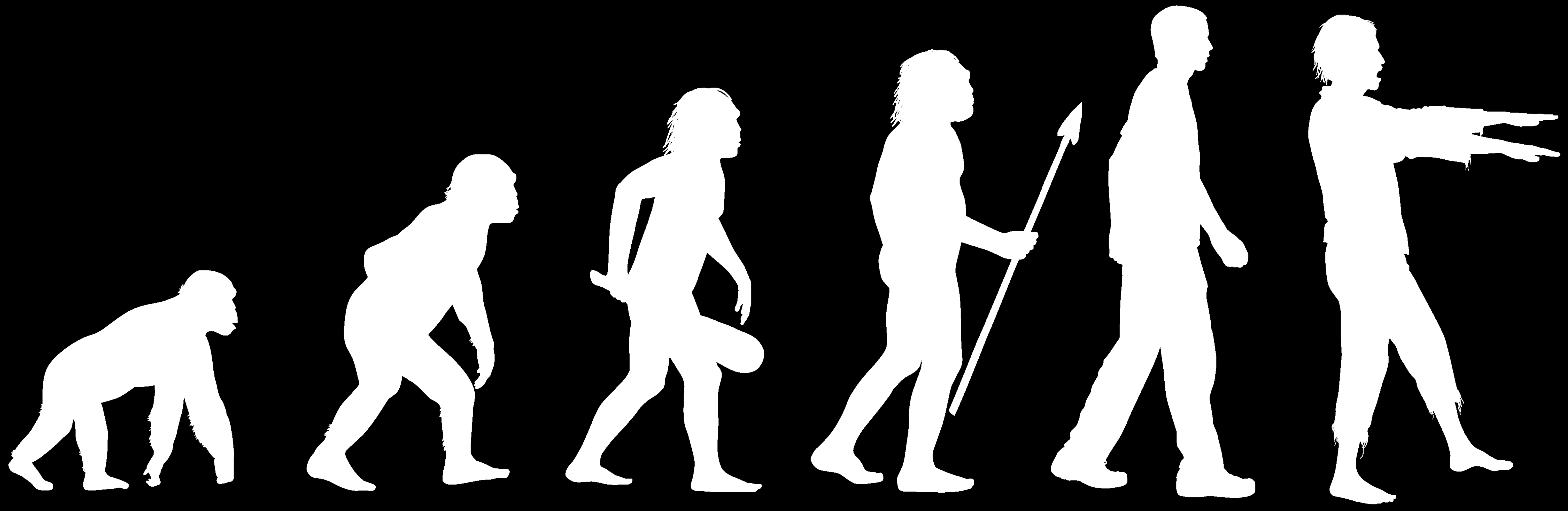
Core Bluetooth in iOS 7.0

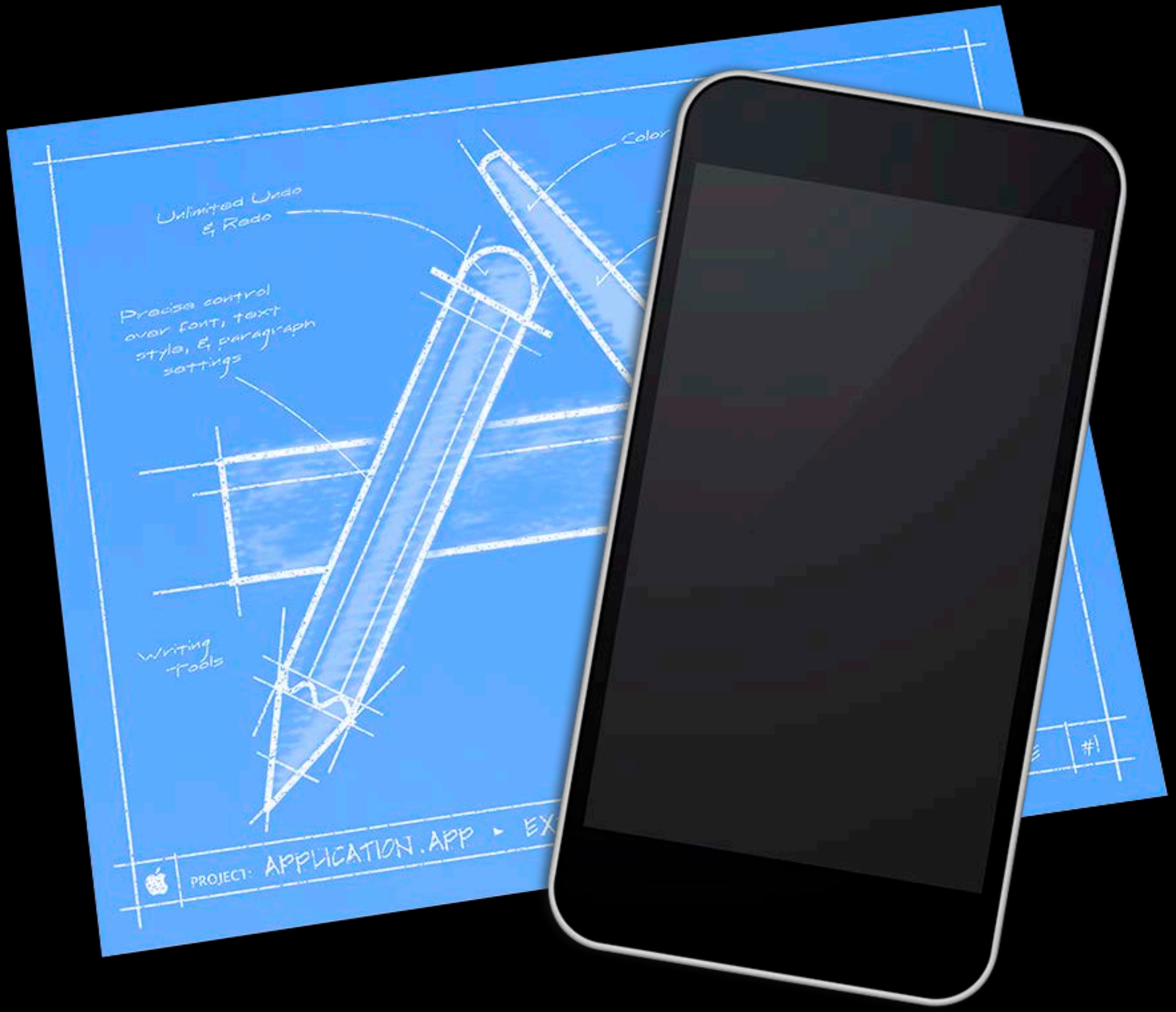
LE, Evolved

What’s New

Ch-ch-ch-changes

- Simpler device management
- Smarter peripherals
- Performance improvements
- Application persistence
- Built-in services

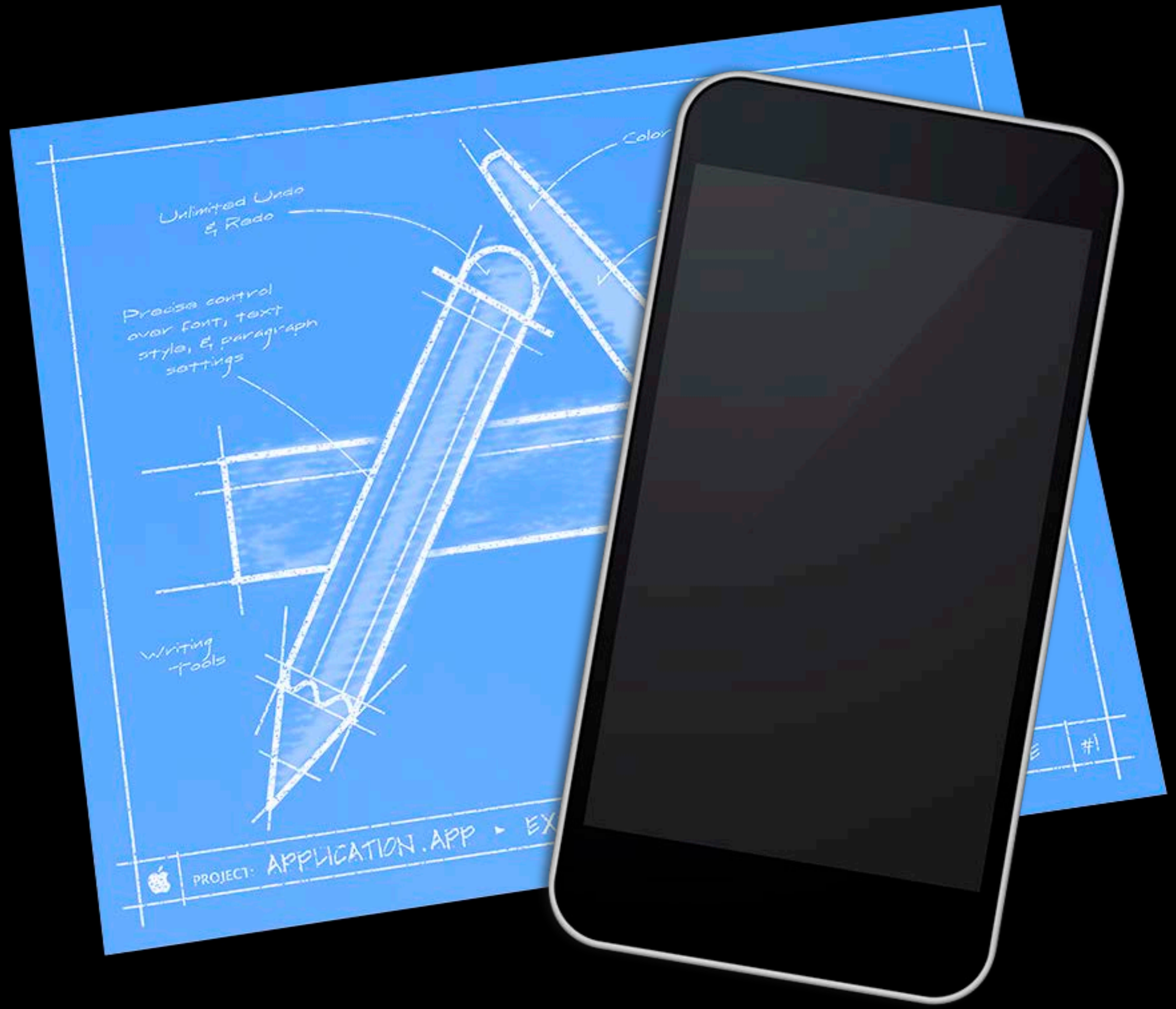



Unlimited Undo
& Redo
Precise control
over font, text
style, & paragraph
settings
Writing
Tools
Color
PROJECT: APPLICATION.APP ▸ EX
#1

To Simulate, or Not to Simulate

That is the question

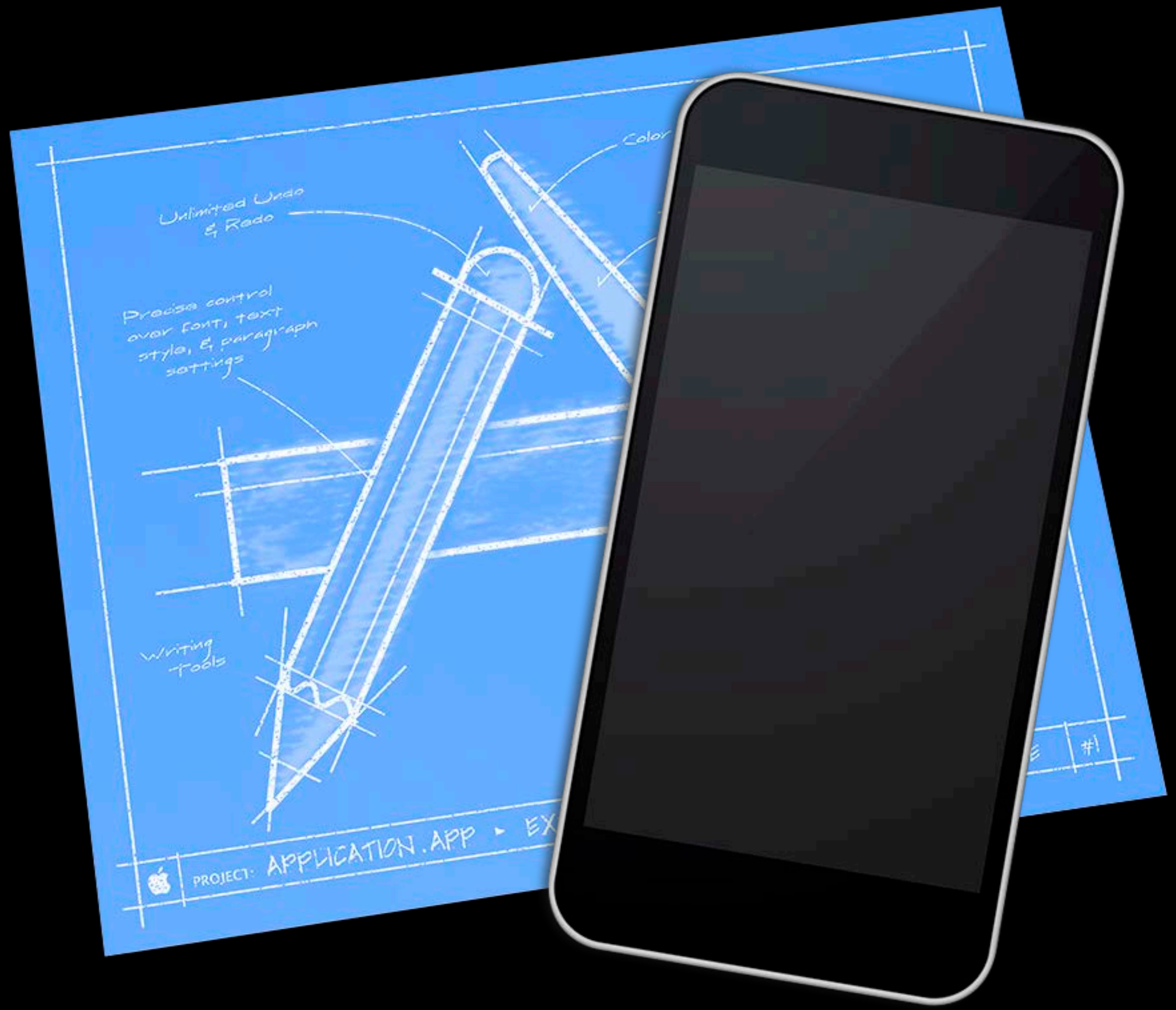
- Emerging market
- Limited hardware available
    - No iOS devices
- Development difficult



To Simulate, or Not to Simulate

That is the question

- Exploding market
- Many LE-compatible devices
  - All iOS hardware
  - Macbook, Mac mini
- Third-party development kits



To Simulate, or Not to Simulate

That is the question

- Exploding market
- Many LE-compatible devices
  - All iOS hardware
  - Macbook, Mac mini
- Third-party development kits

To Simulate, or Not to Simulate

That is the question

- Exploding market
- Many LE-compatible devices
  - All iOS hardware
  - Most Mac hardware
- Third-party development kits

Simpler Device Management

Handling centrals and peripherals

Simpler Device Management

Handling centrals and peripherals

- Bye, bye CoreFoundation

```
@property(readonly, nonatomic) CFUUIDRef *UUID;
```

Simpler Device Management

Handling centrals and peripherals

- Bye, bye CoreFoundation

~~@property(readonly, nonatomic) CFUUIDRef *UUID;~~

```
@property(readonly, nonatomic) NSUUID *identifier;
```

Simpler Device Management

Handling centrals and peripherals

- Bye, bye CoreFoundation

~~@property(readonly, nonatomic) CFUUIDRef *UUID;~~

```
@property(readonly, nonatomic) NSUUID *identifier;
```

- Identifiers created at discovery

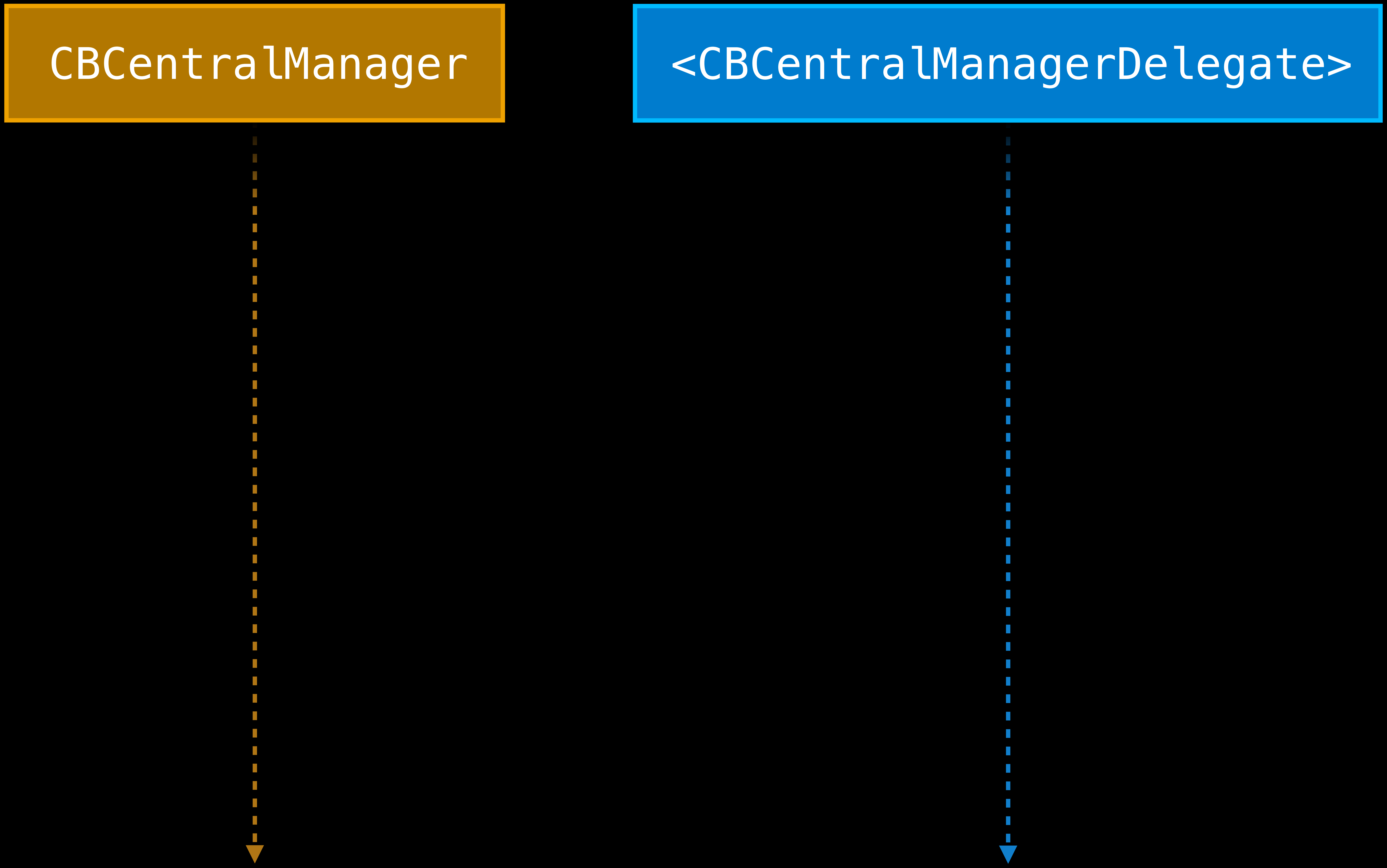
Simpler Device Management

Retrieving peripherals, today

CBCentralManager
<CBCentralManagerDelegate>

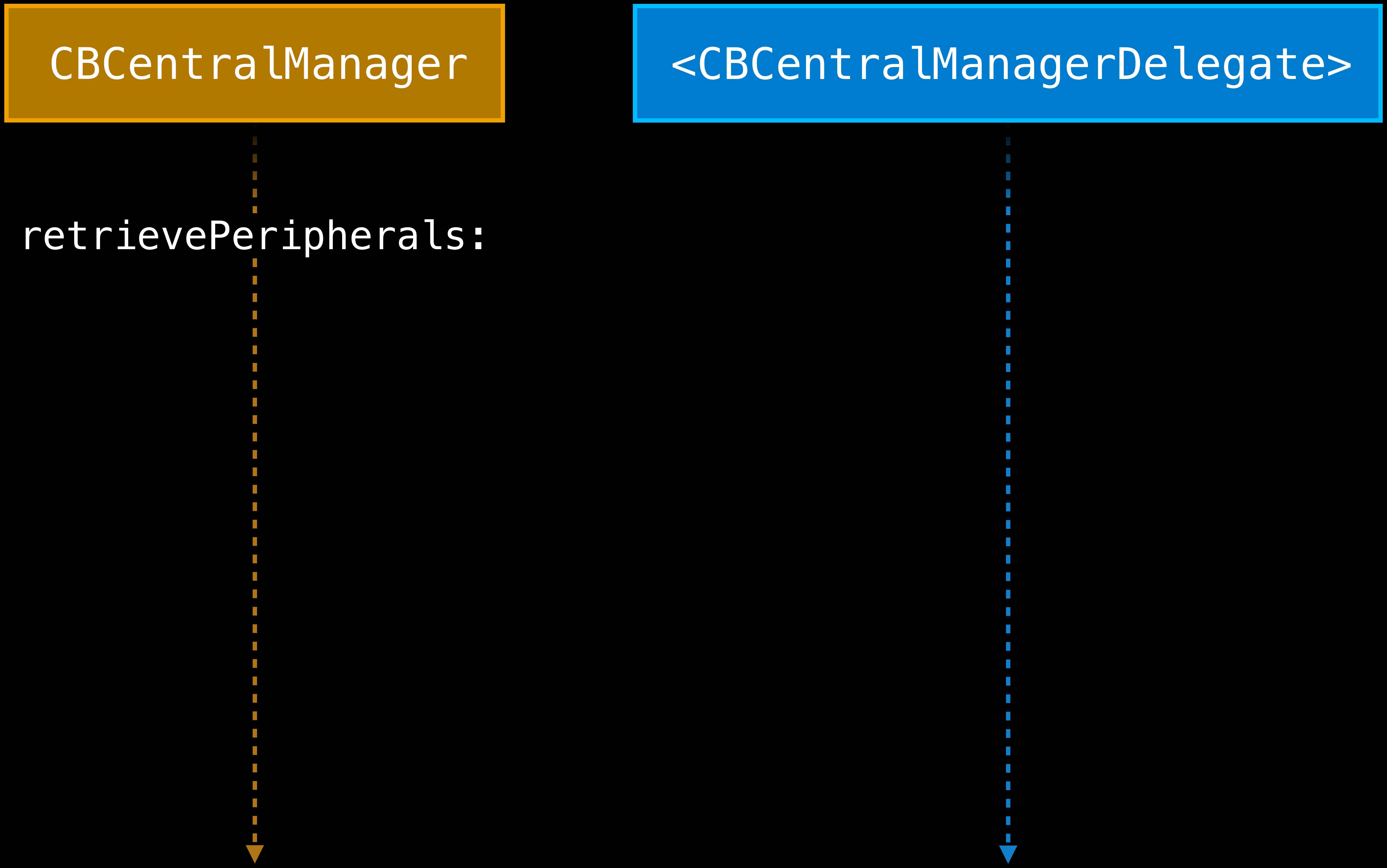
Simpler Device Management

Retrieving peripherals, today



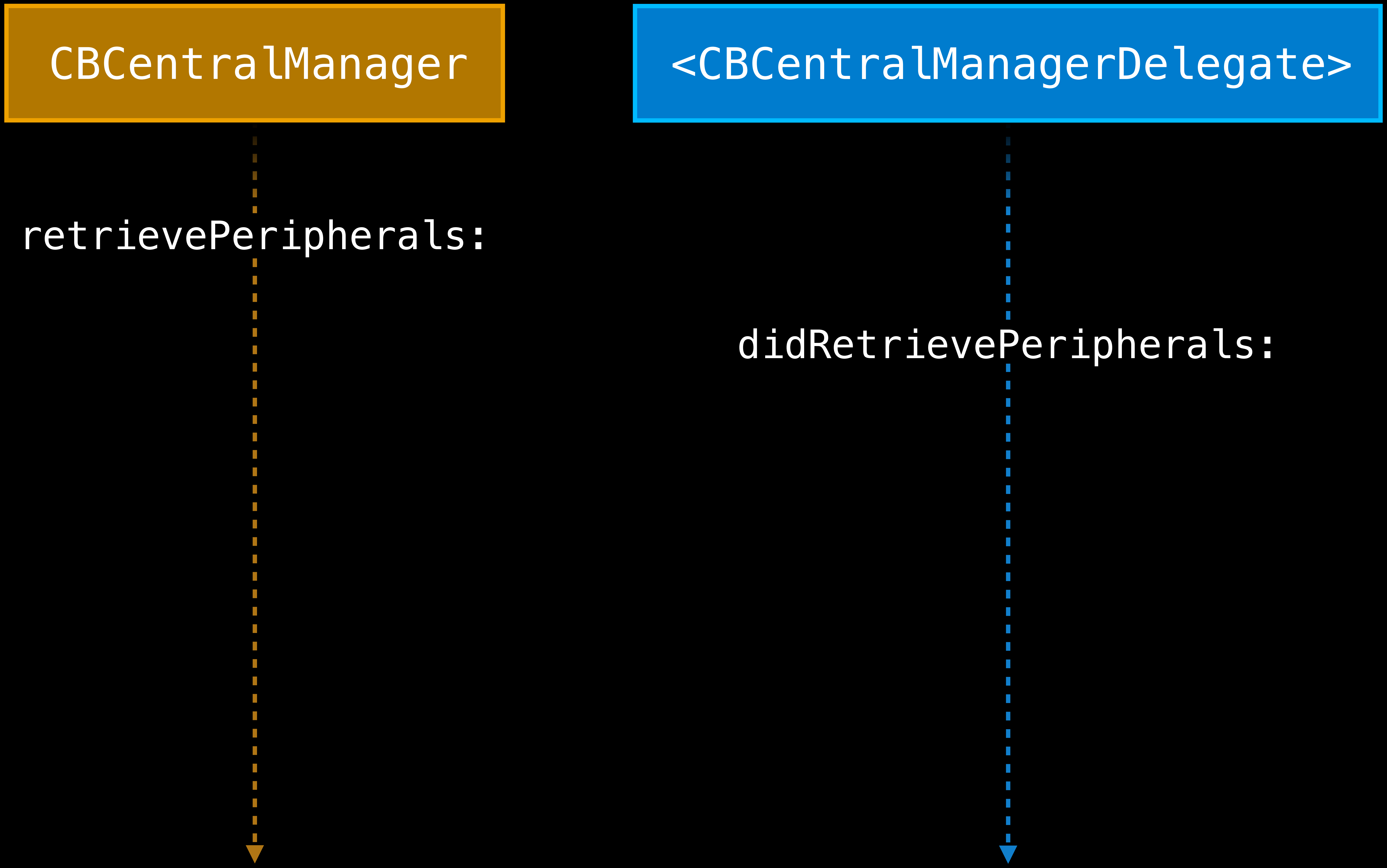
Simpler Device Management

Retrieving peripherals, today



Simpler Device Management

Retrieving peripherals, today



CBCentralManager

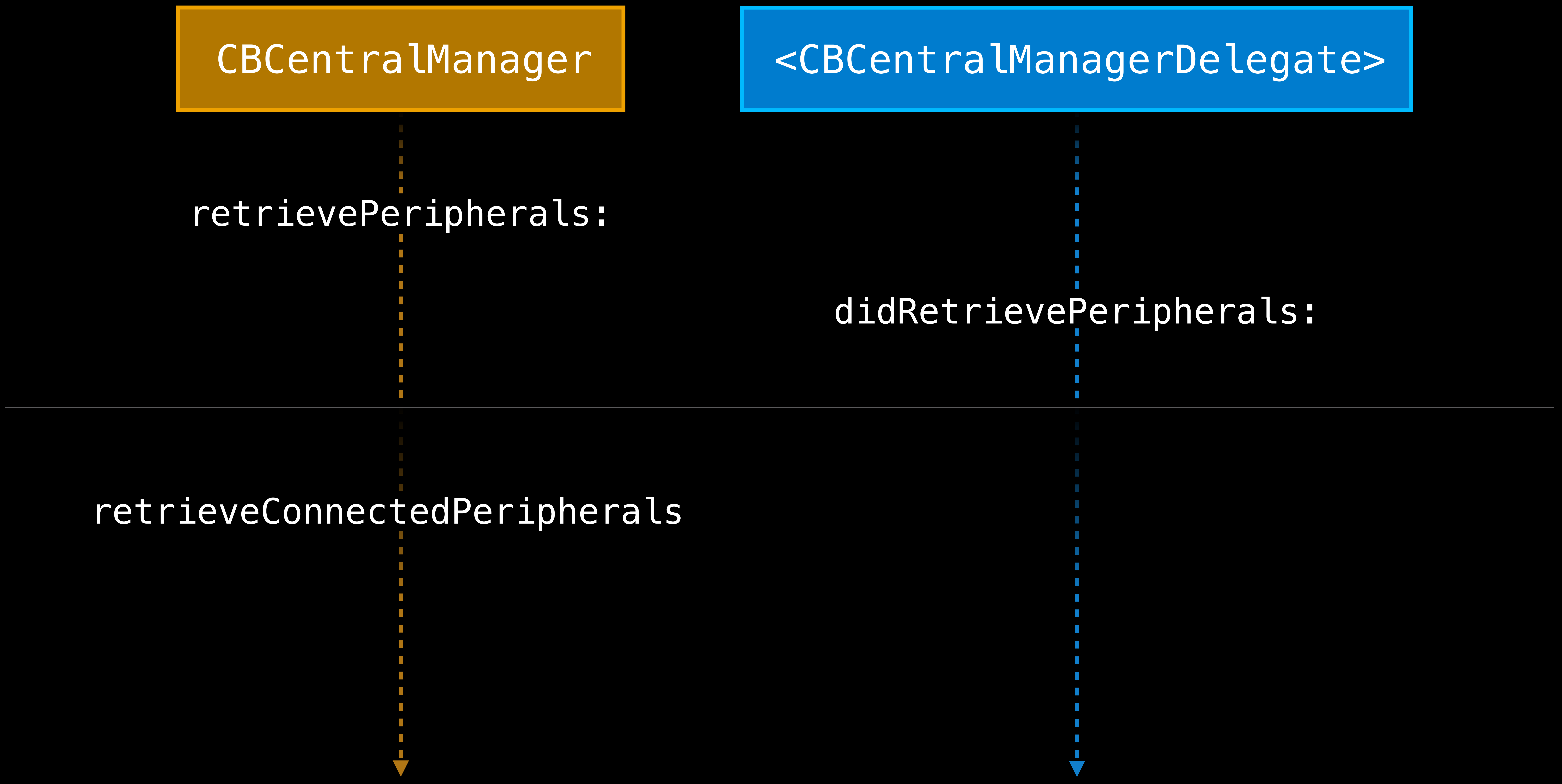
<CBCentralManagerDelegate>

retrievePeripherals:

didRetrievePeripherals:

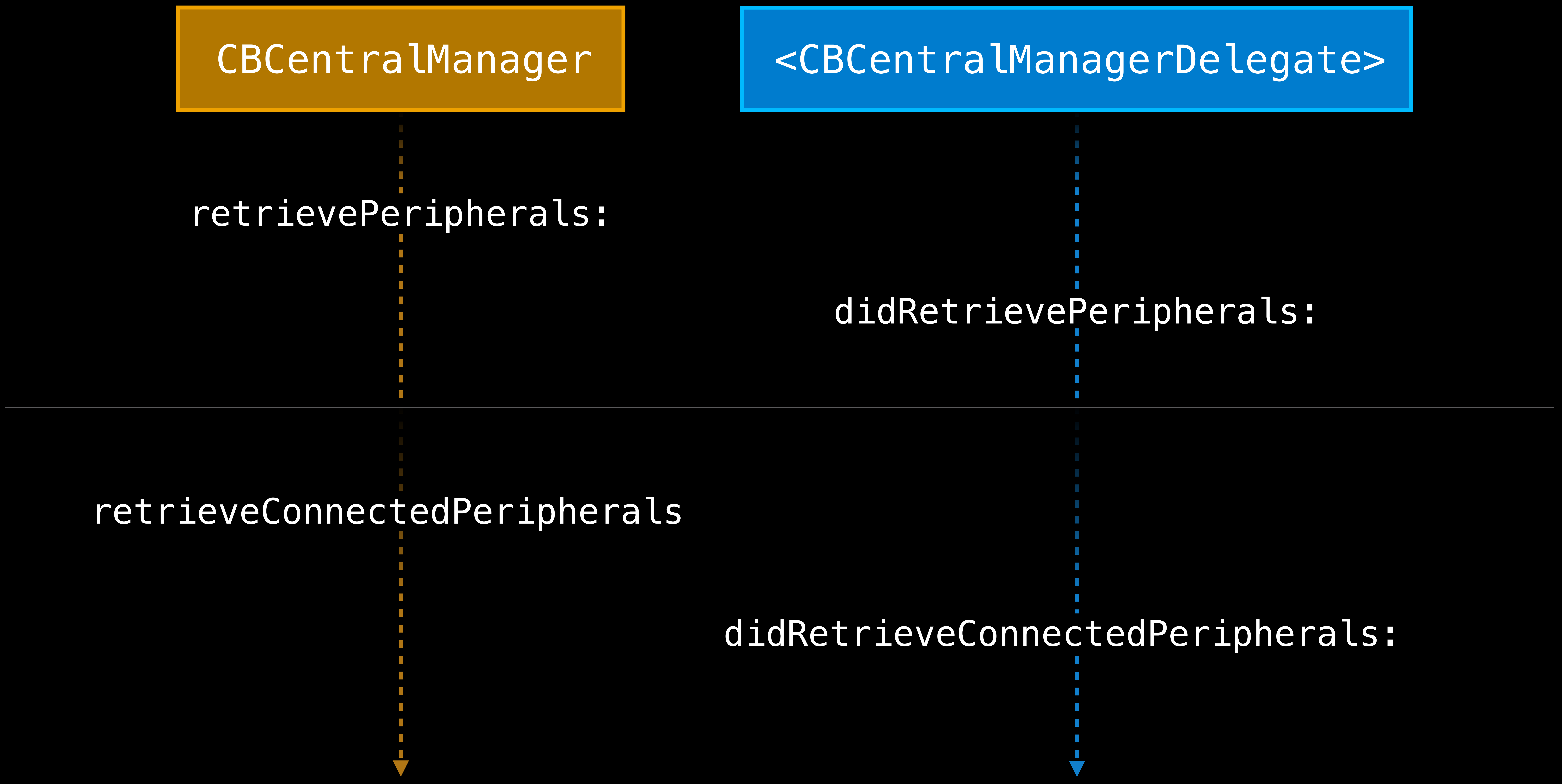
Simpler Device Management

Retrieving peripherals, today



Simpler Device Management

Retrieving peripherals, today



CBCentralManager

<CBCentralManagerDelegate>

retrievePeripherals:

didRetrievePeripherals:

retrieveConnectedPeripherals

didRetrieveConnectedPeripherals:

Simpler Device Management

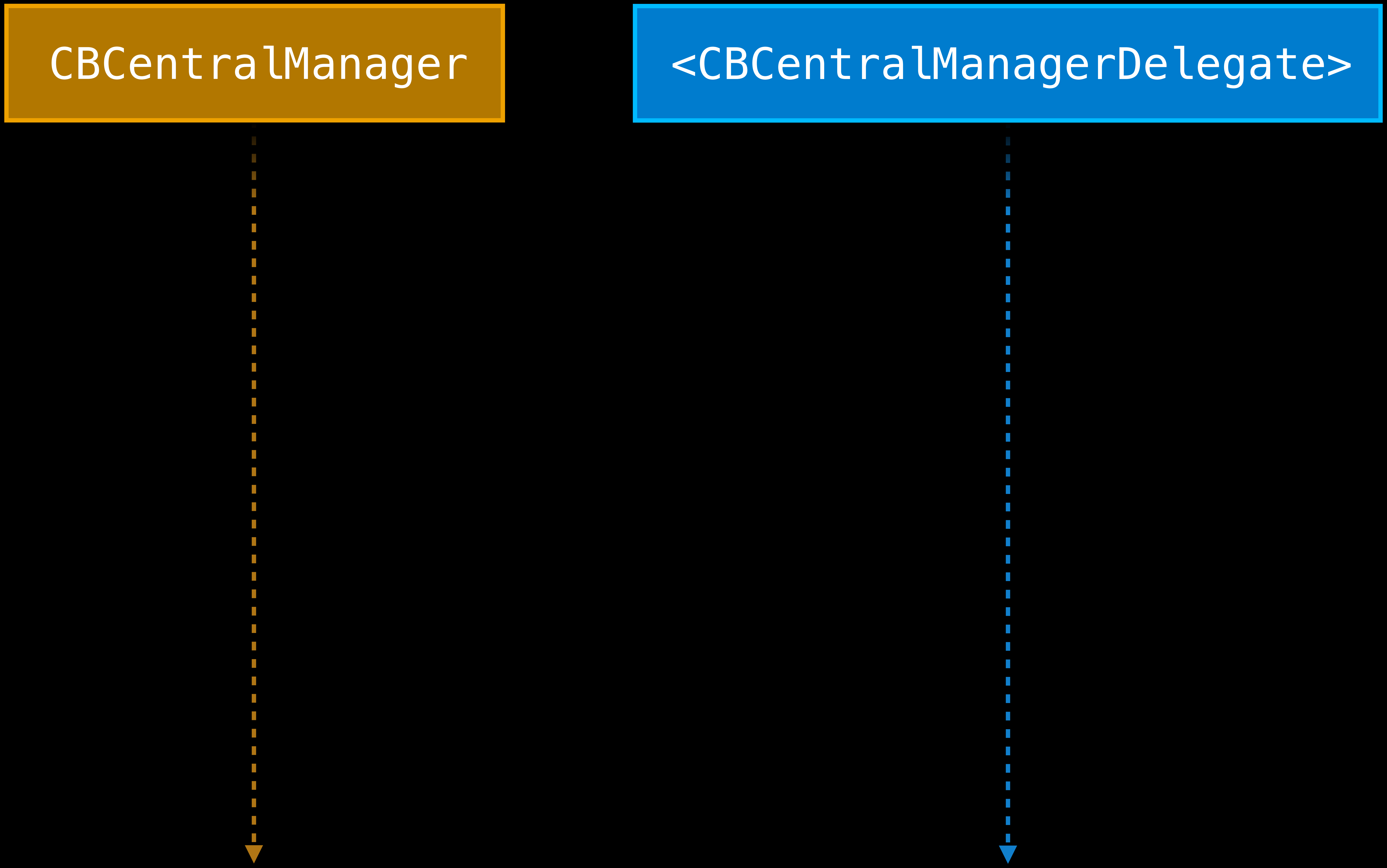
Retrieving peripherals

CBCentralManager

<CBCentralManagerDelegate>

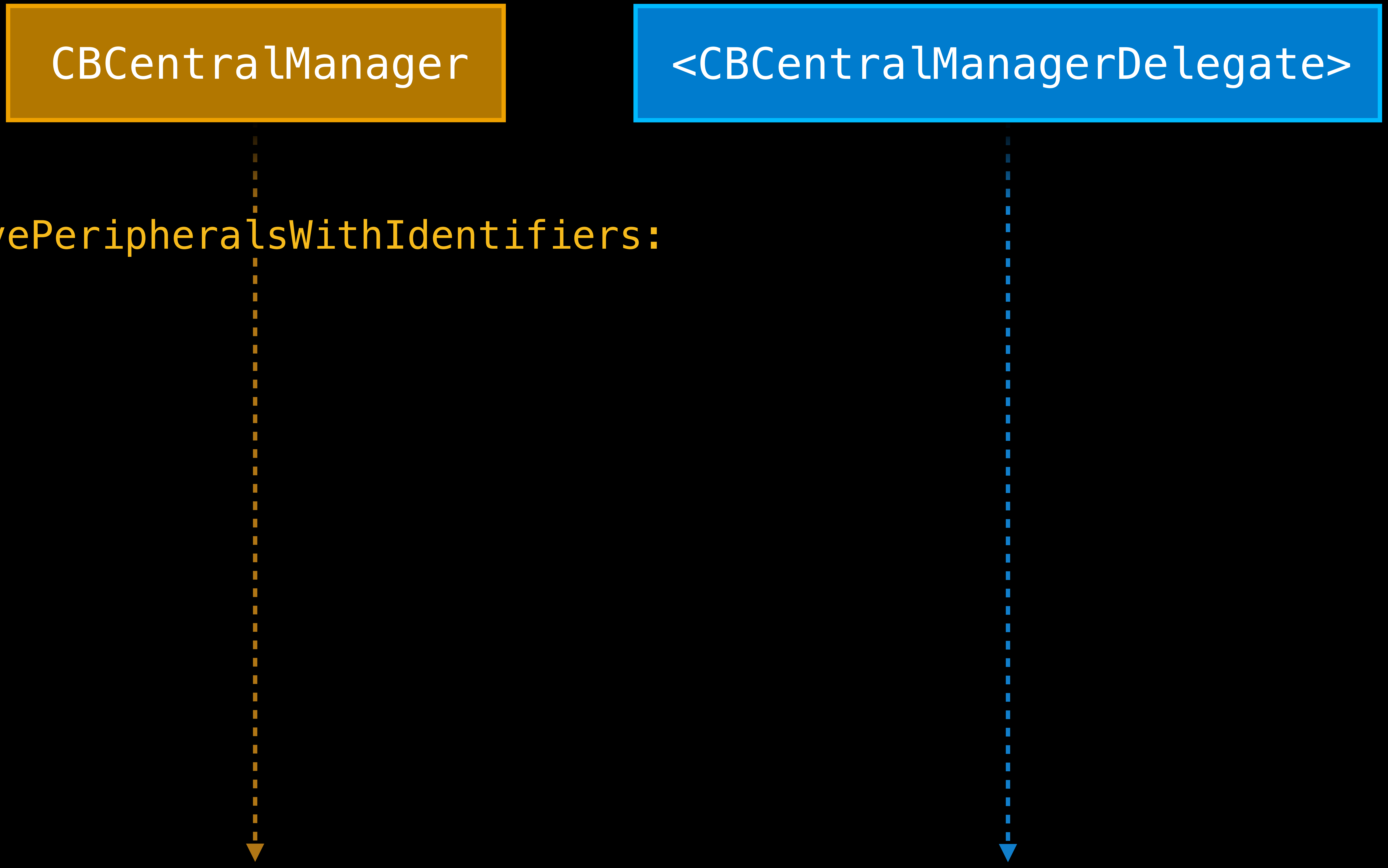
Simpler Device Management

Retrieving peripherals



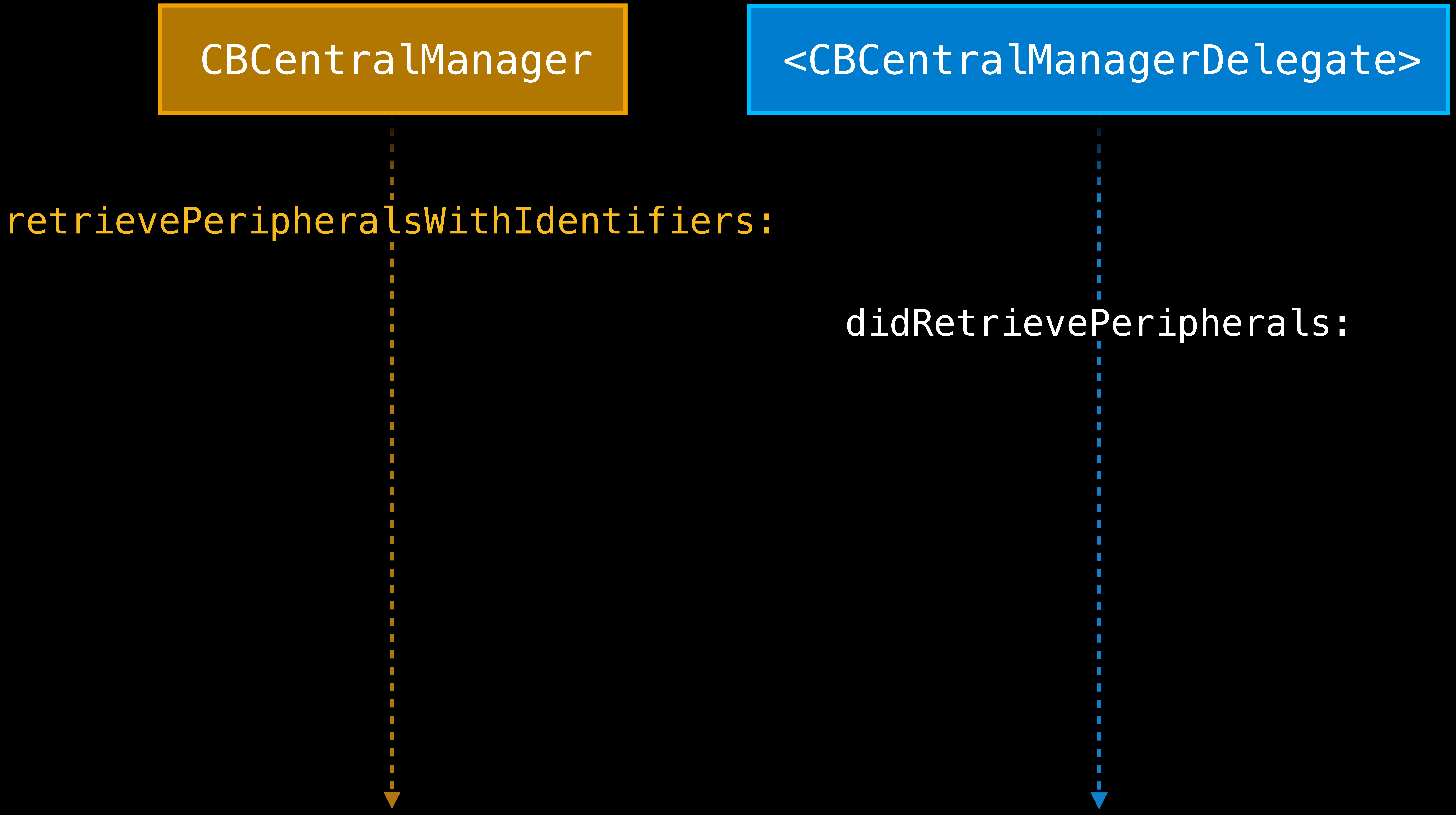
Simpler Device Management

Retrieving peripherals


CBCentralManager
<CBCentralManagerDelegate>
retrievePeripheralsWithIdentifiers:

Simpler Device Management

Retrieving peripherals



CBCentralManager

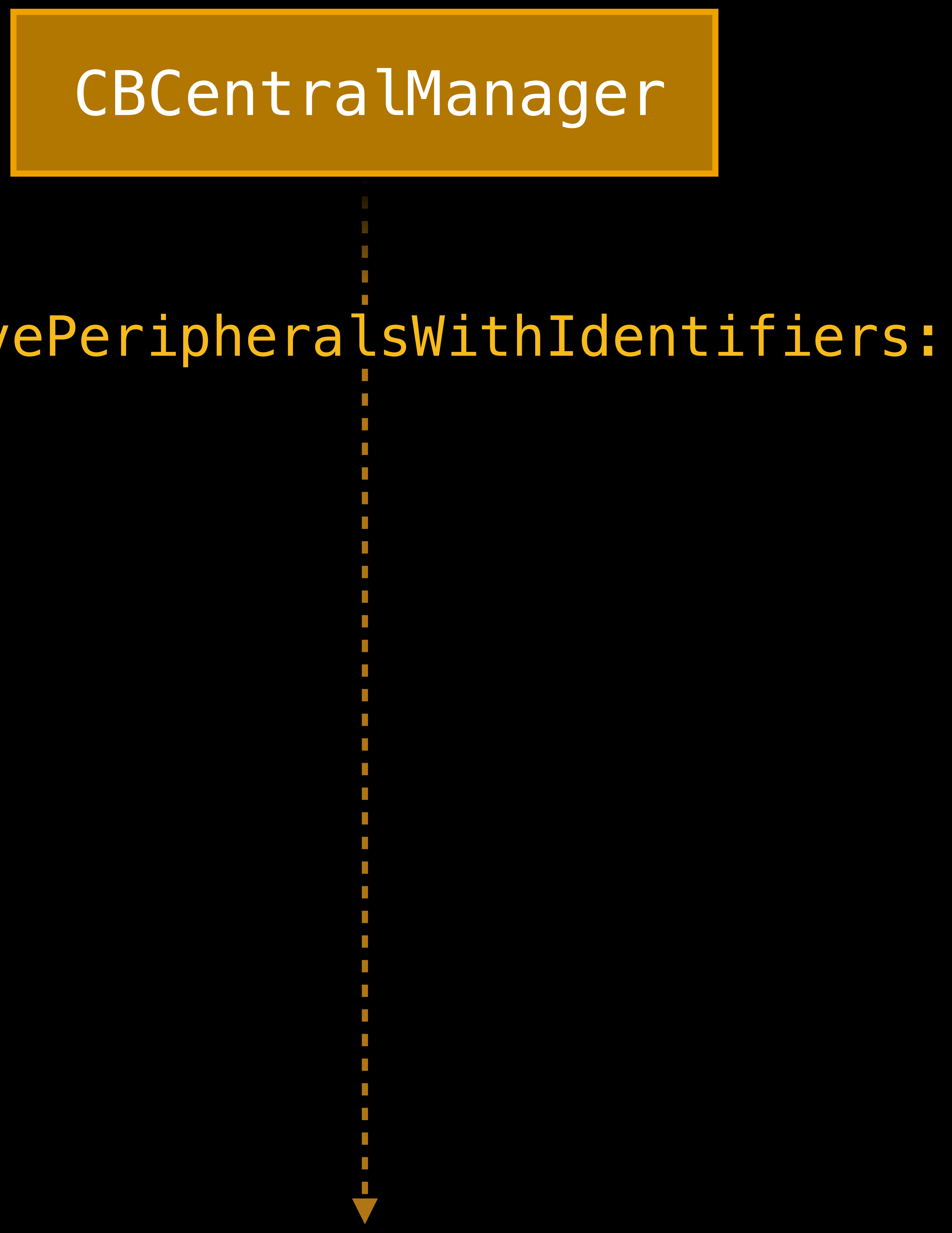
<CBCentralManagerDelegate>

retrievePeripheralsWithIdentifiers:

didRetrievePeripherals:

Simpler Device Management

Retrieving peripherals, the iOS 7 way



CBCentralManager

retrievePeripheralsWithIdentifiers:

Simpler Device Management

Retrieving peripherals, the iOS 7 way

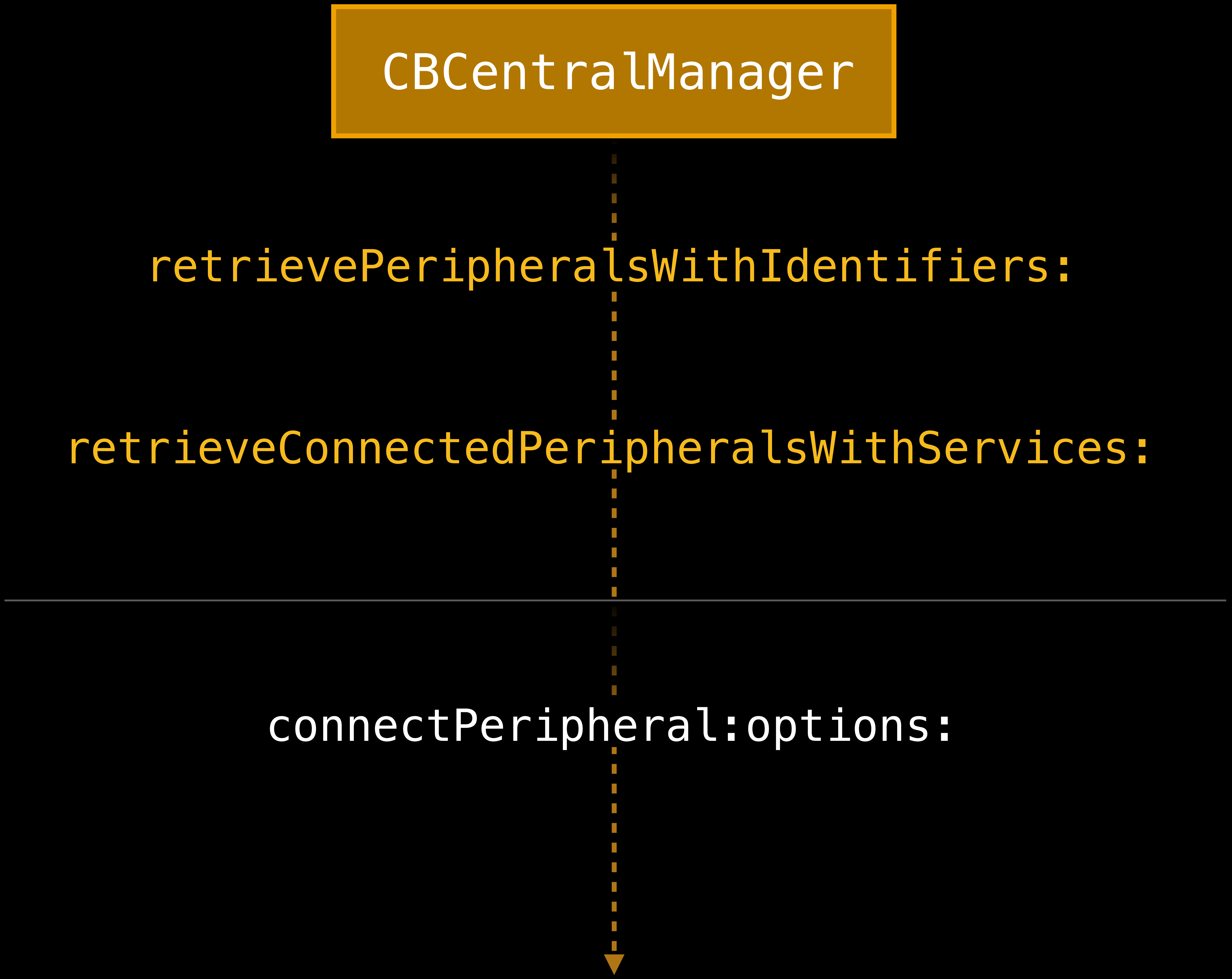
CBCentralManager

retrievePeripheralsWithIdentifiers:

retrieveConnectedPeripheralsWithServices:

Simpler Device Management

Retrieving peripherals, the iOS 7 way



CBCentralManager

retrievePeripheralsWithIdentifiers:

retrieveConnectedPeripheralsWithServices:

connectPeripheral:options:

Smarter Peripherals

Smarter Peripherals

- More connection-aware

```
@property(readonly) BOOL isConnected;
```

Smarter Peripherals

- More connection-aware

~~@property(readonly) BOOL isConnected;~~

```
typedef NS_ENUM(NSInteger, CBPeripheralState) {
   CBPeripheralStateDisconnected = 0,
   CBPeripheralStateConnecting,
   CBPeripheralStateConnected };

@property(readonly) CBPeripheralState state;
```

Smarter Peripherals

Smarter Peripherals

- Better service invalidation

Smarter Peripherals

- Better service invalidation

```
(void)peripheralDidInvalidateServices:(CBPeripheral *)
```

Smarter Peripherals

- Better service invalidation

~~(void)peripheralDidInvalidateServices:(CBPeripheral *)~~

```
(void)peripheral:(CBPeripheral *)didModifyServices:(NSArray *)
```

Core Bluetooth in iOS 7.0

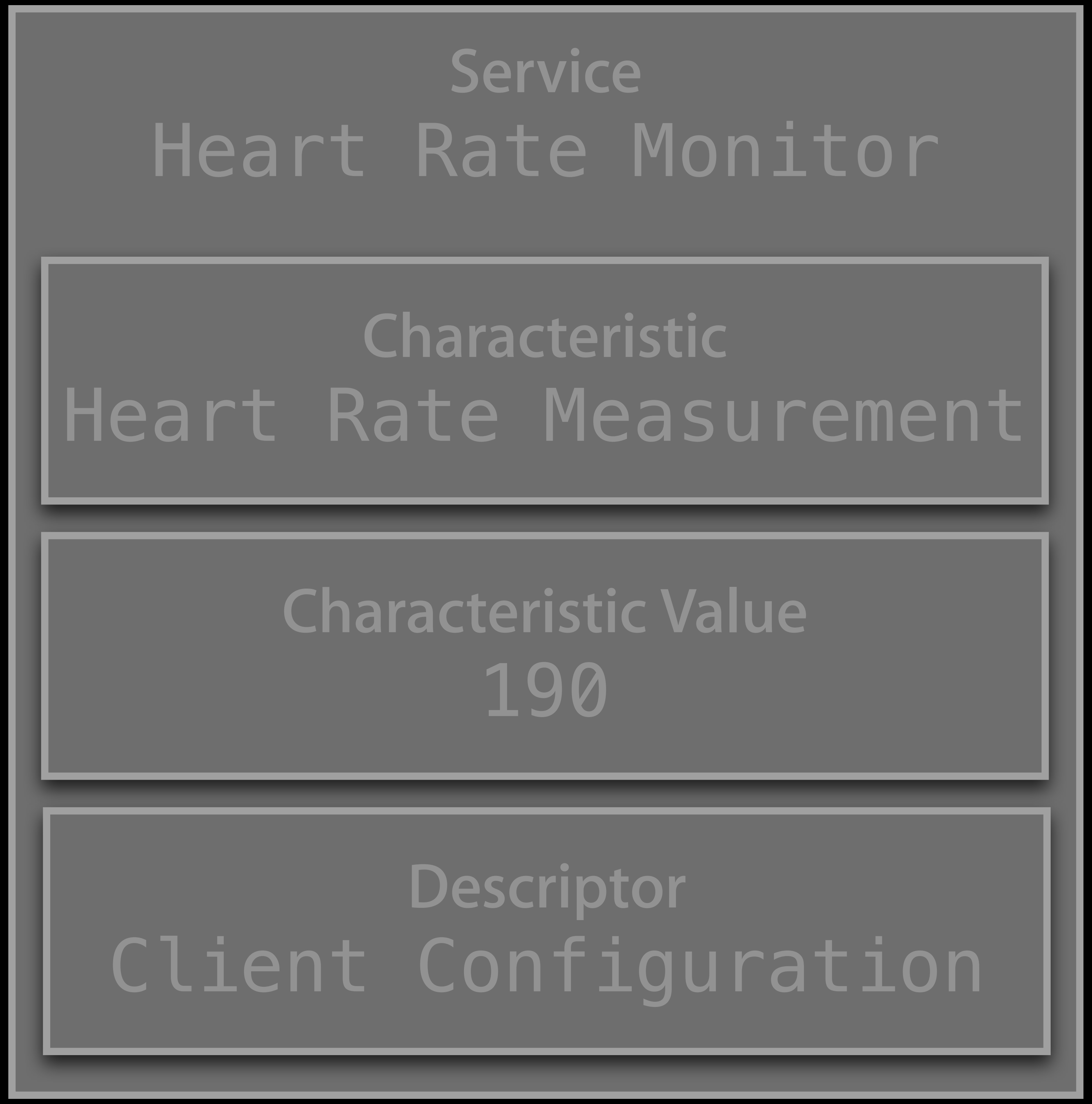
LE, Evolved

Jason Conn
Code Monkey & Radio Sponge

Performance Improvements

Performance Improvements

Database caching, today



Service
Heart Rate Monitor

Characteristic
Heart Rate Measurement

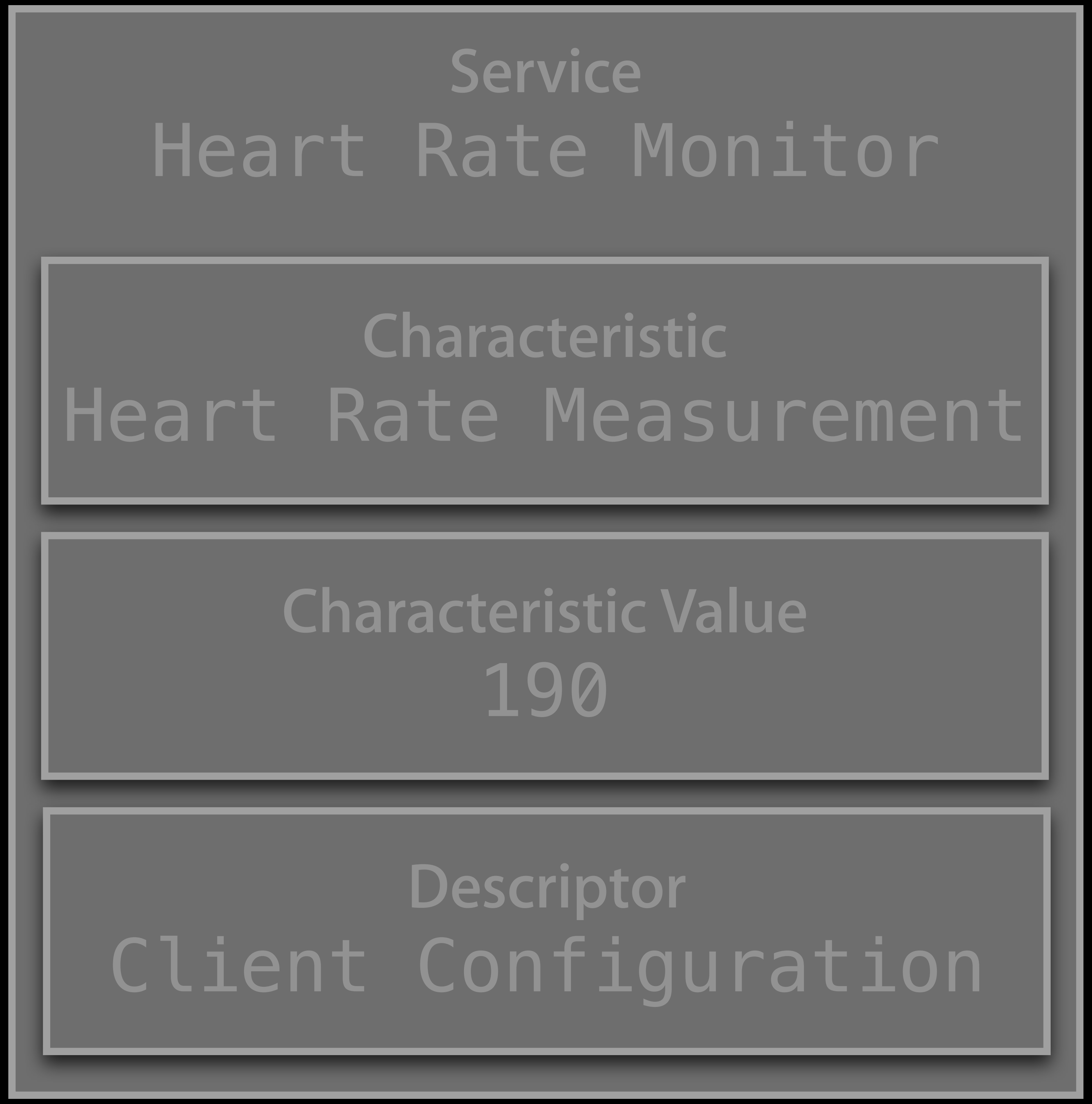
Characteristic Value
190

Descriptor
Client Configuration

Performance Improvements

Database caching, today

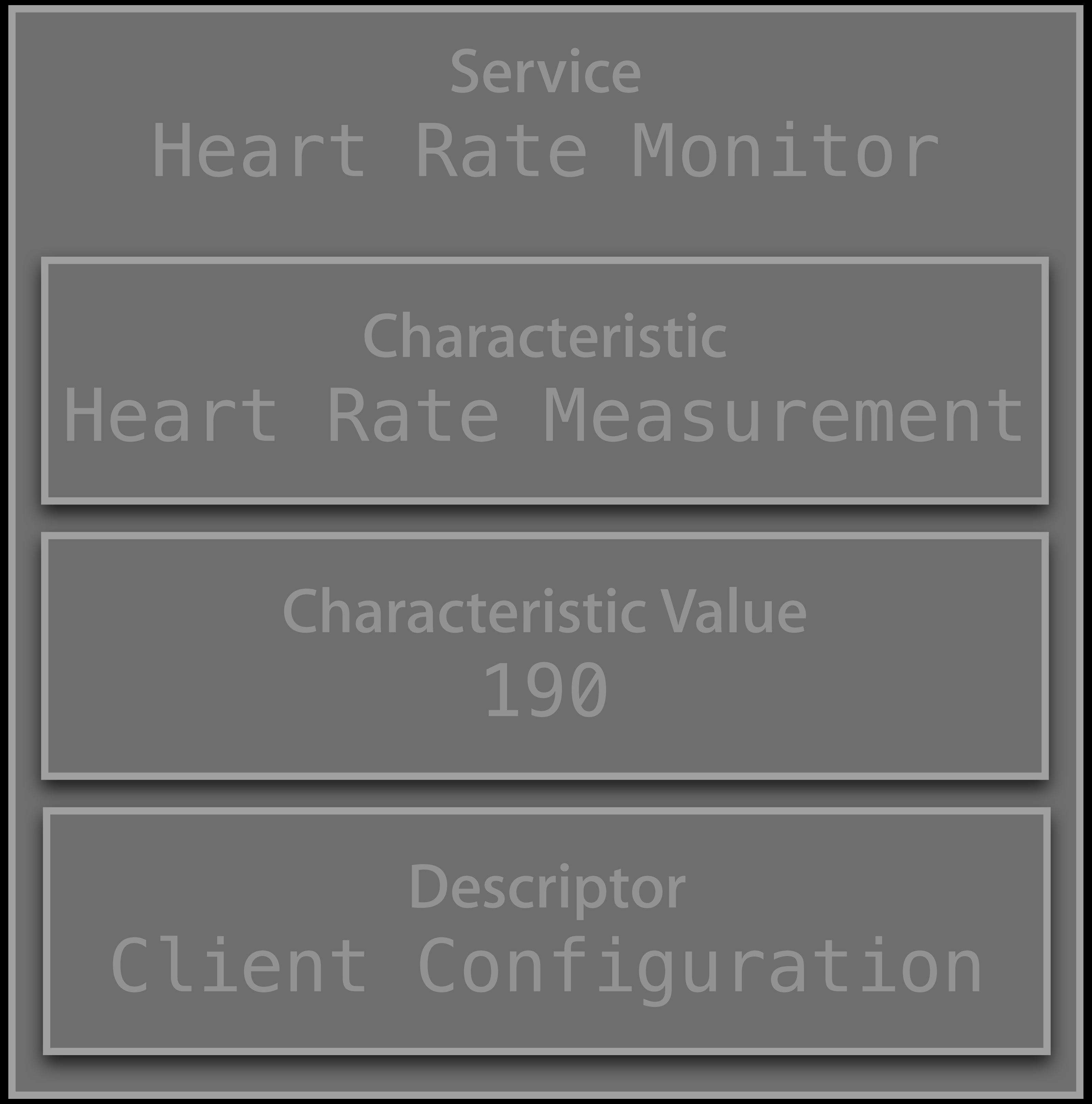
- Introduced in iOS 6



Performance Improvements

Database caching, today

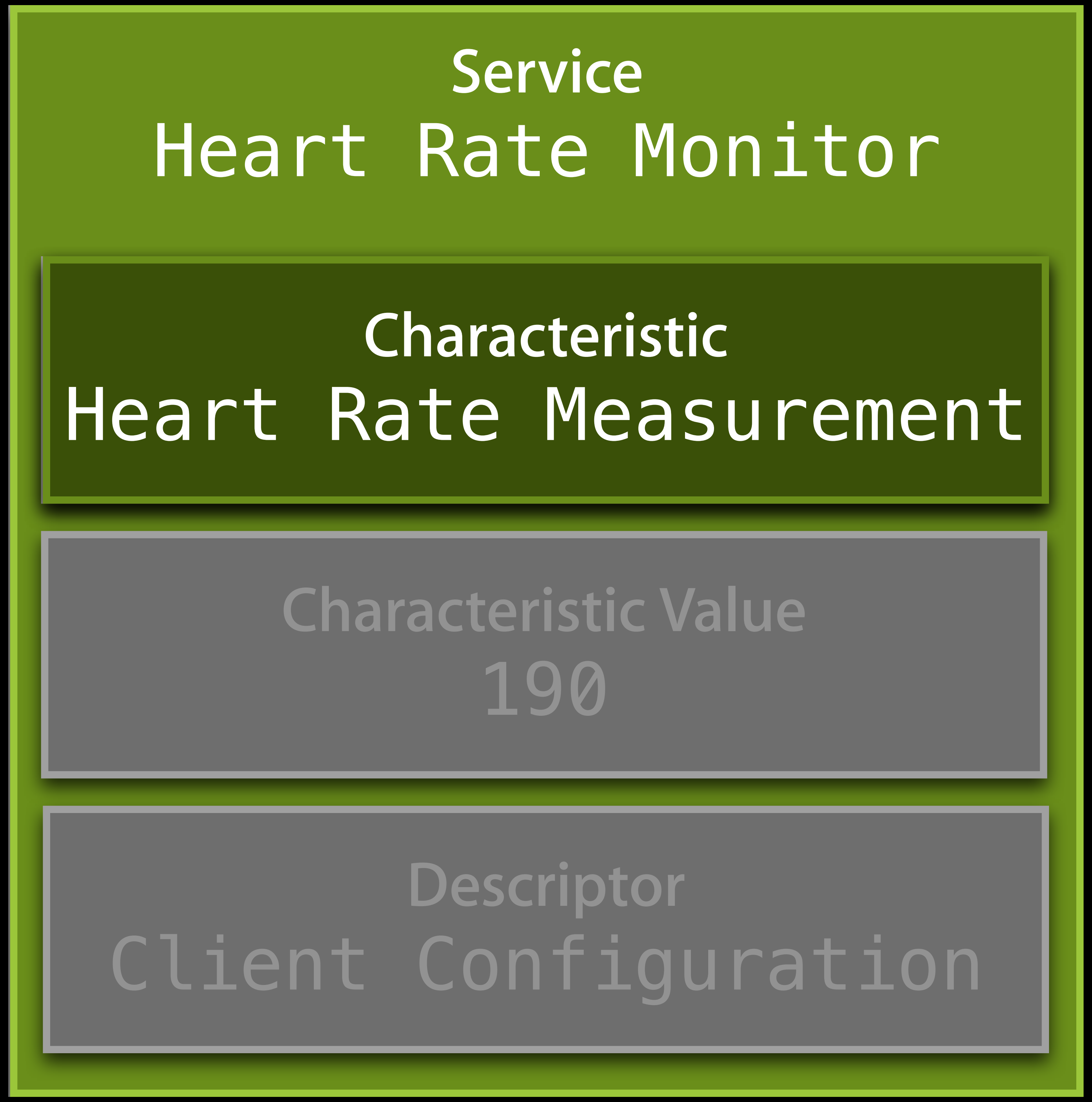
- Introduced in iOS 6
- Increases speed and battery life



Performance Improvements

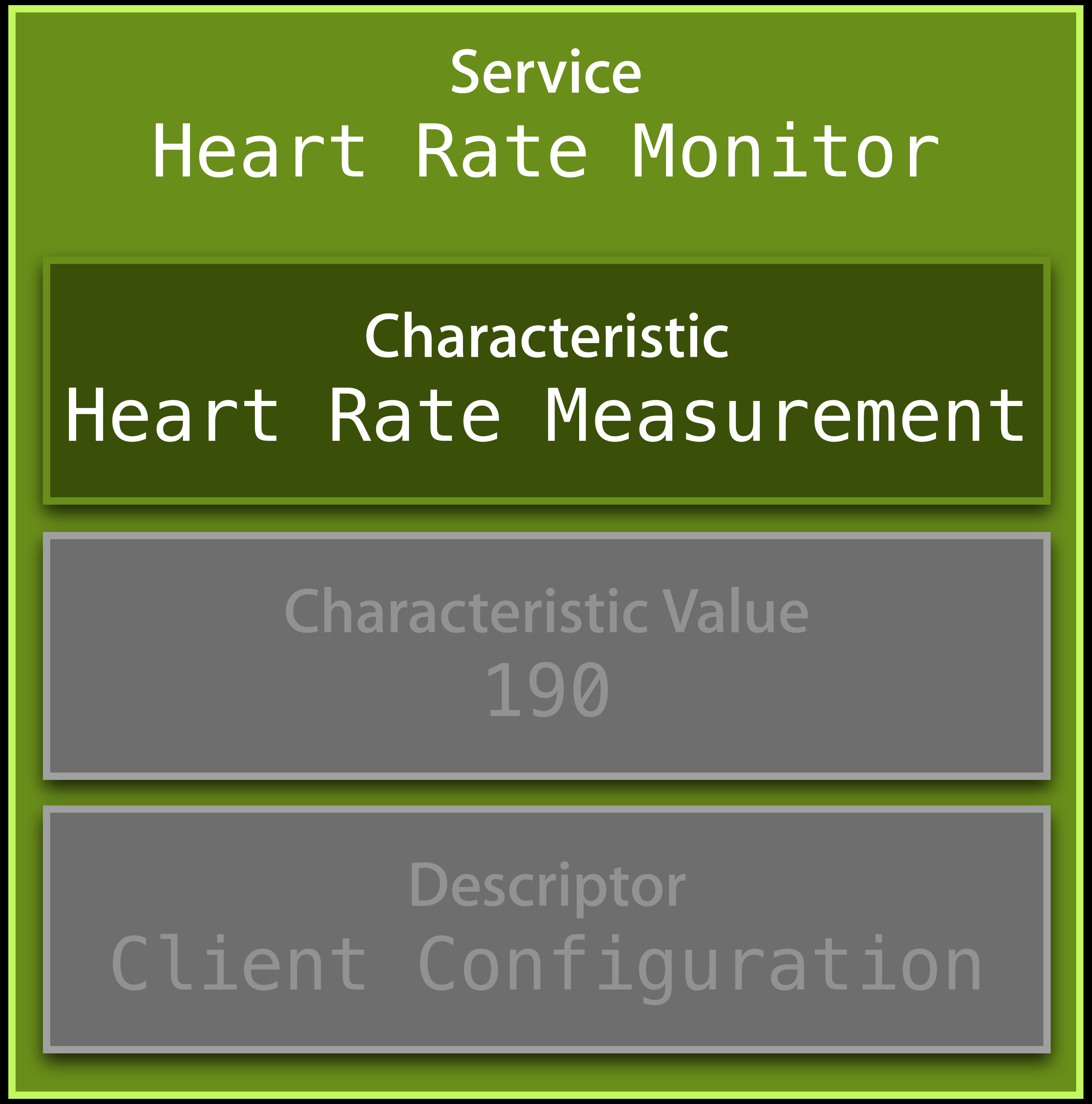
Database caching, today

- Introduced in iOS 6
- Increases speed and battery life
- Cache services and characteristics


Service
Heart Rate Monitor
Characteristic
Heart Rate Measurement
Characteristic Value
190
Descriptor
Client Configuration

Performance Improvements

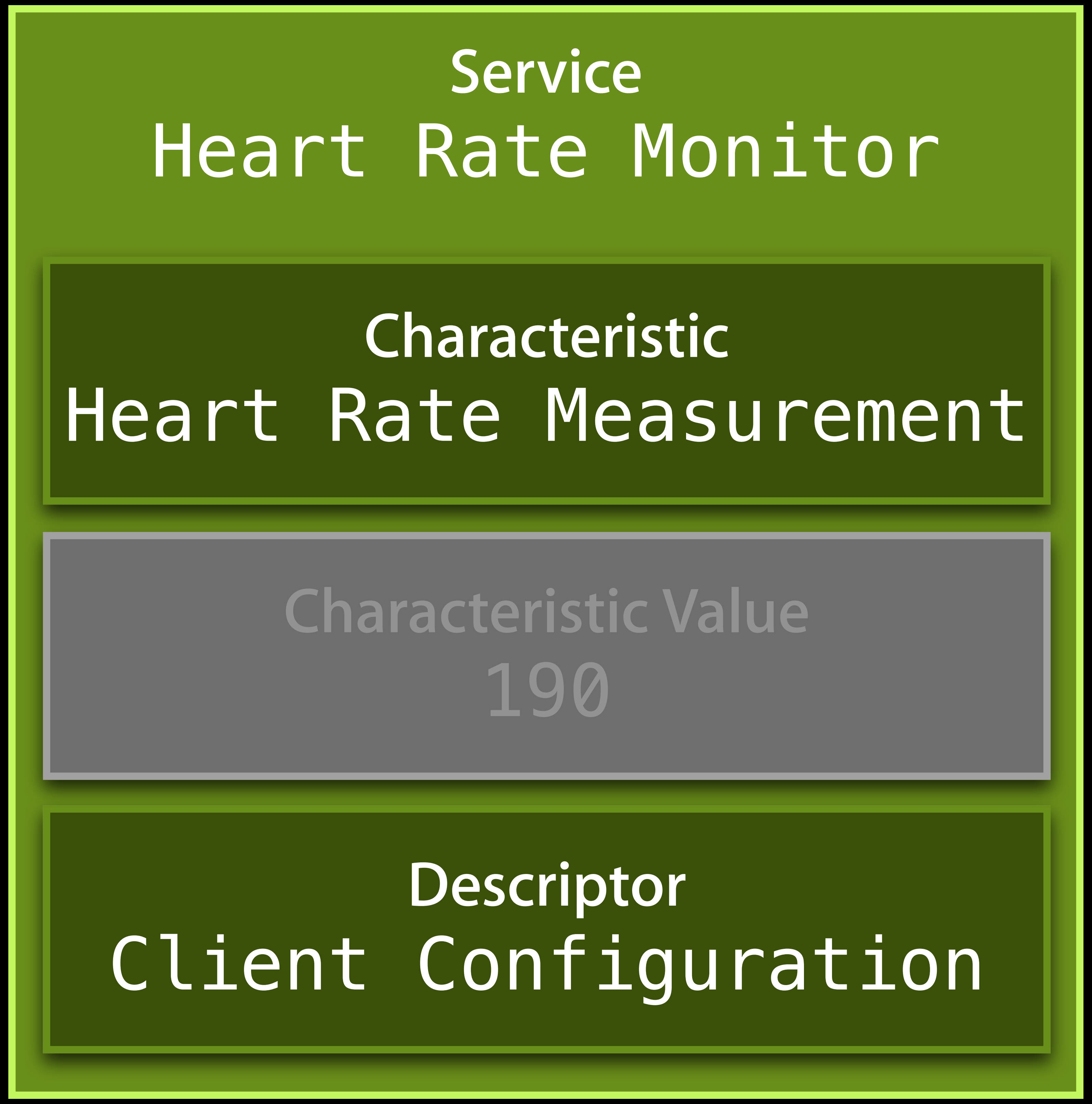
Database caching, in iOS 7



Performance Improvements

Database caching, in iOS 7

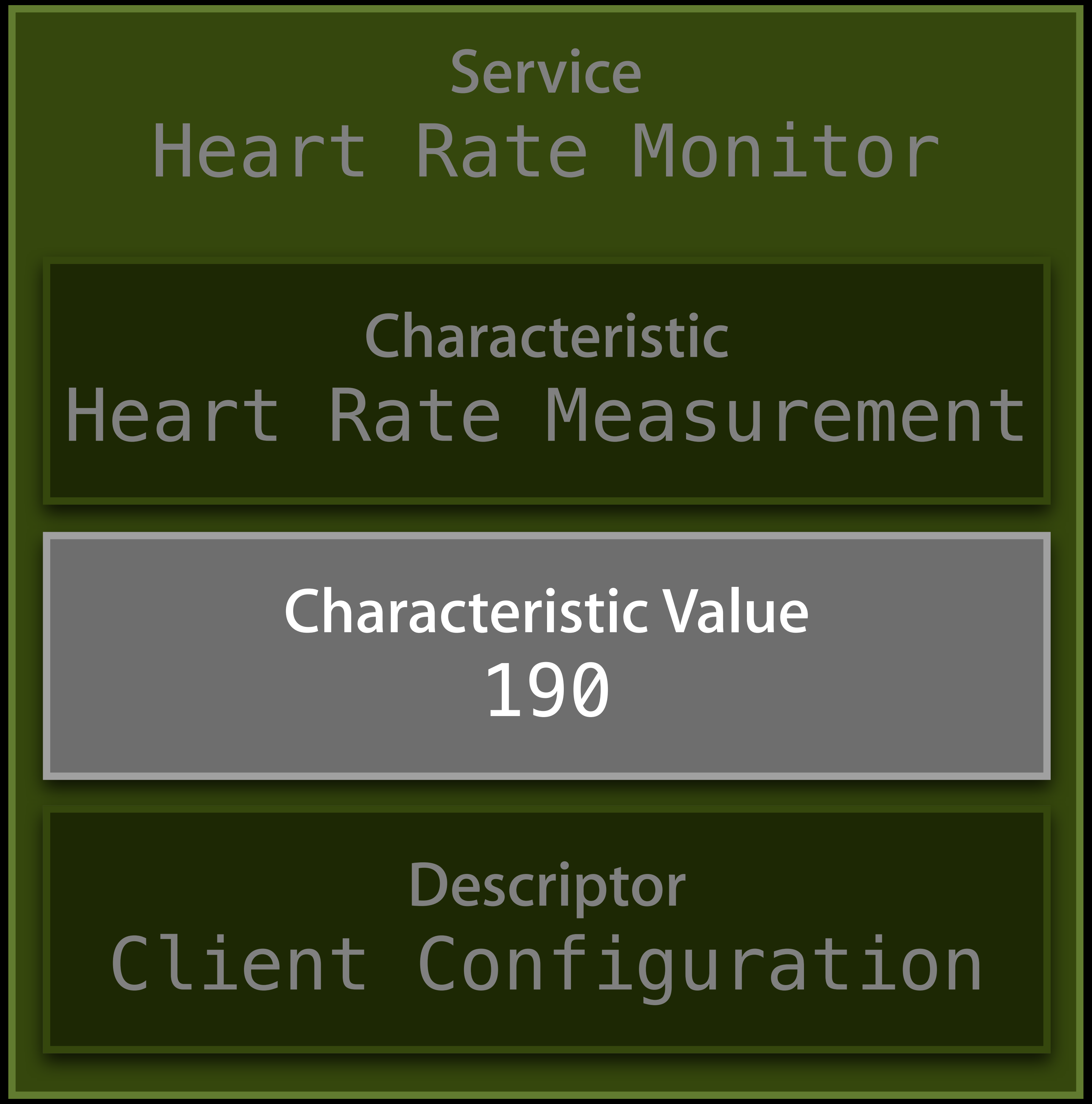
- Cache characteristic descriptors



Performance Improvements

Database caching, in iOS 7

- Cache characteristic descriptors
- Caching for characteristic values?



Service
Heart Rate Monitor

Characteristic
Heart Rate Measurement

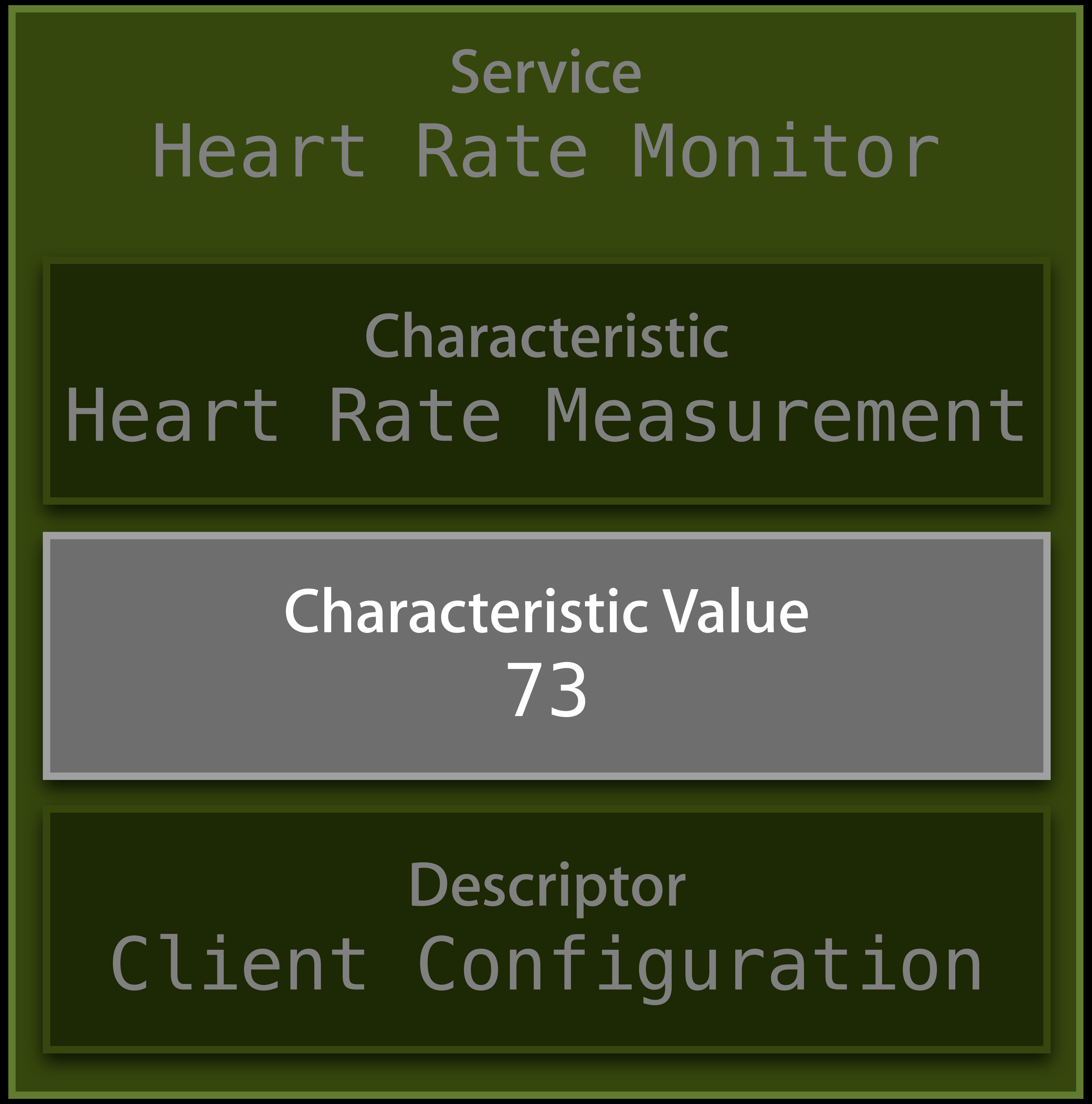
Characteristic Value
190

Descriptor
Client Configuration

Performance Improvements

Database caching, in iOS 7

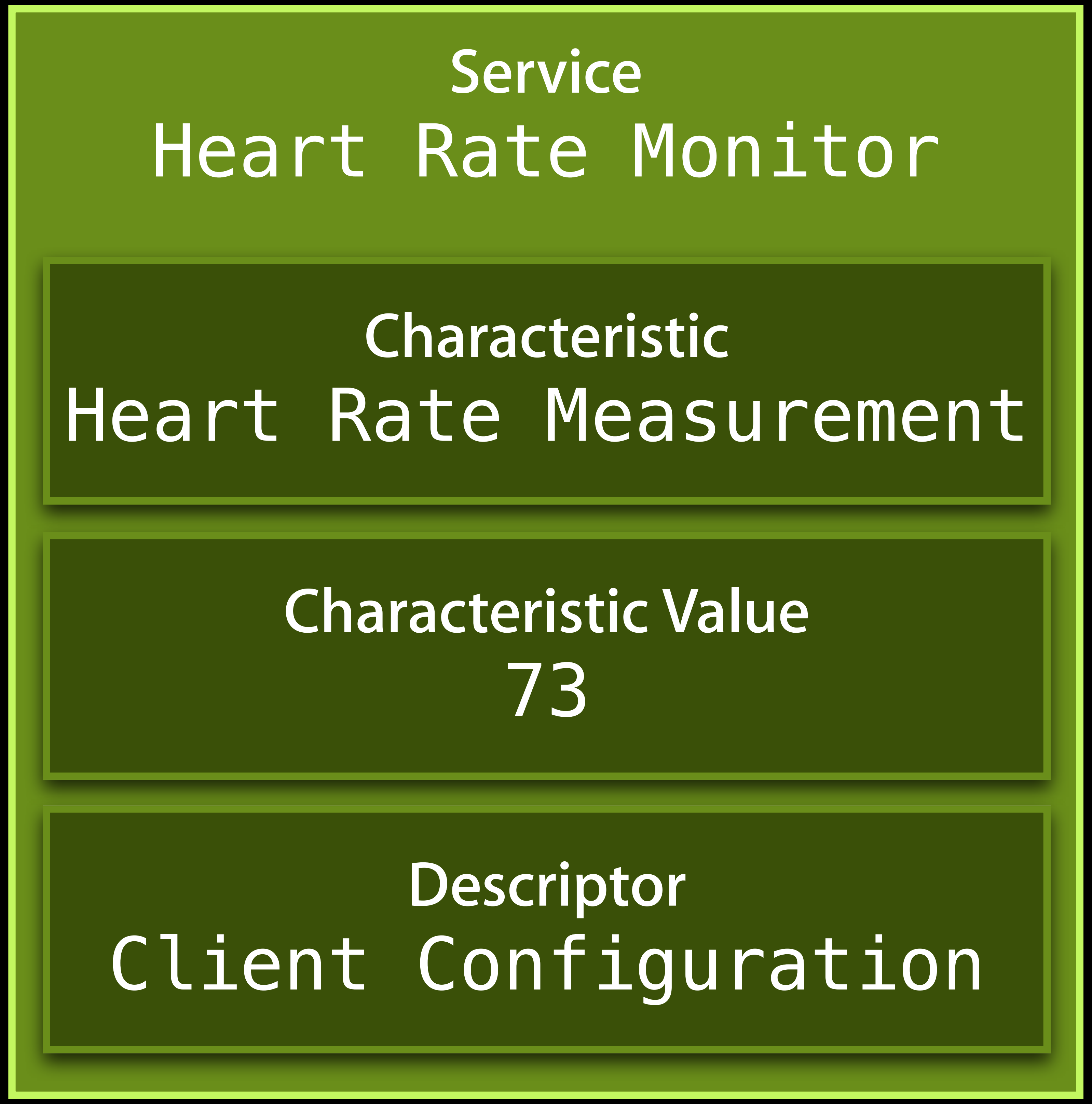
- Cache characteristic descriptors
- Caching for characteristic values?



Performance Improvements

Database caching, in iOS 7

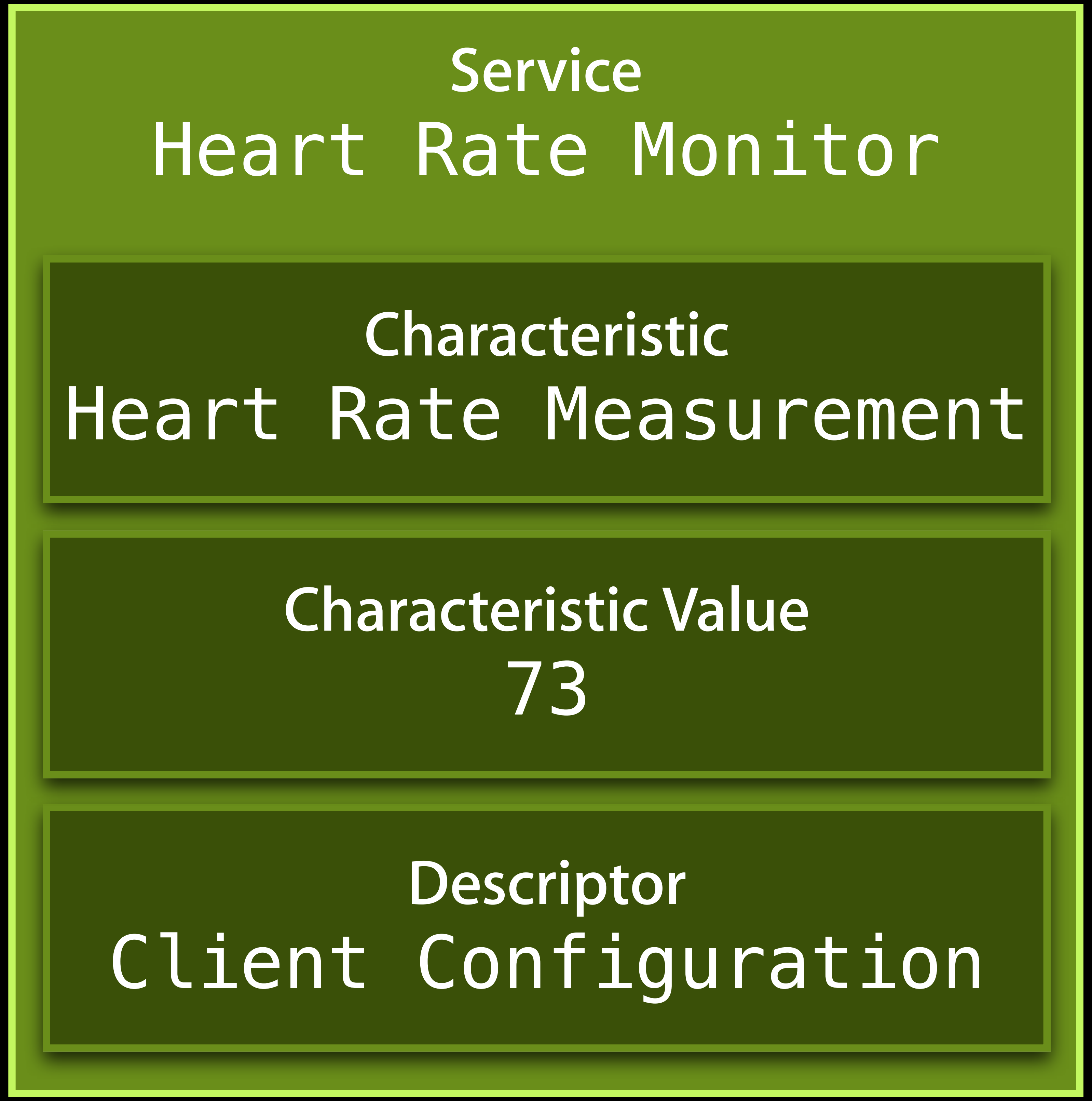
- Cache characteristic descriptors
- Caching for characteristic values?
  - Provide last-known characteristic values and descriptor values



Performance Improvements

Database caching, in iOS 7

- Cache characteristic descriptors
- Caching for characteristic values?
  - Provide last-known characteristic values and descriptor values
- Free!



Performance Improvements

Performance Improvements

Sending data

Performance Improvements

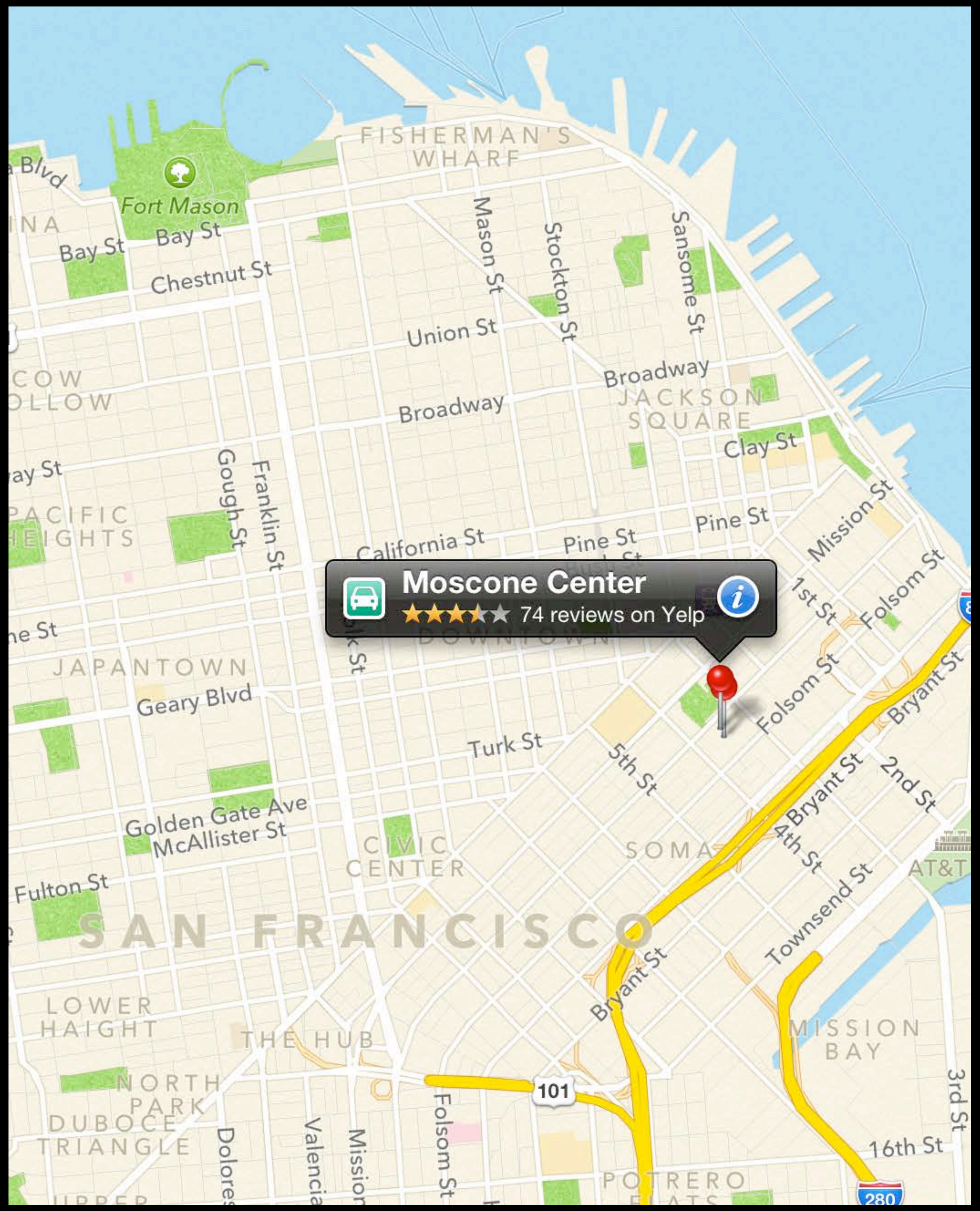
Sending data

115 BPM

Performance Improvements

Sending data

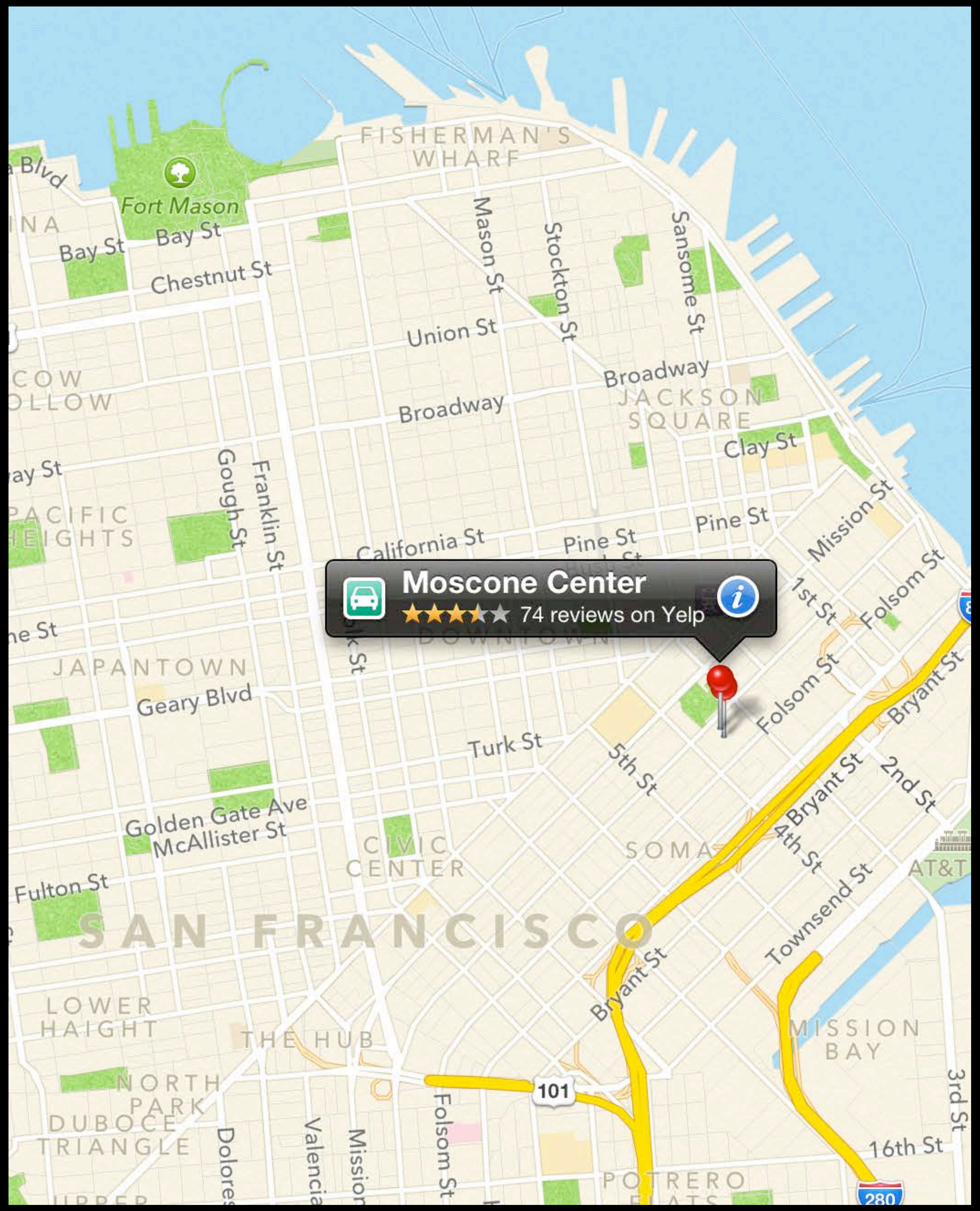
115 BPM

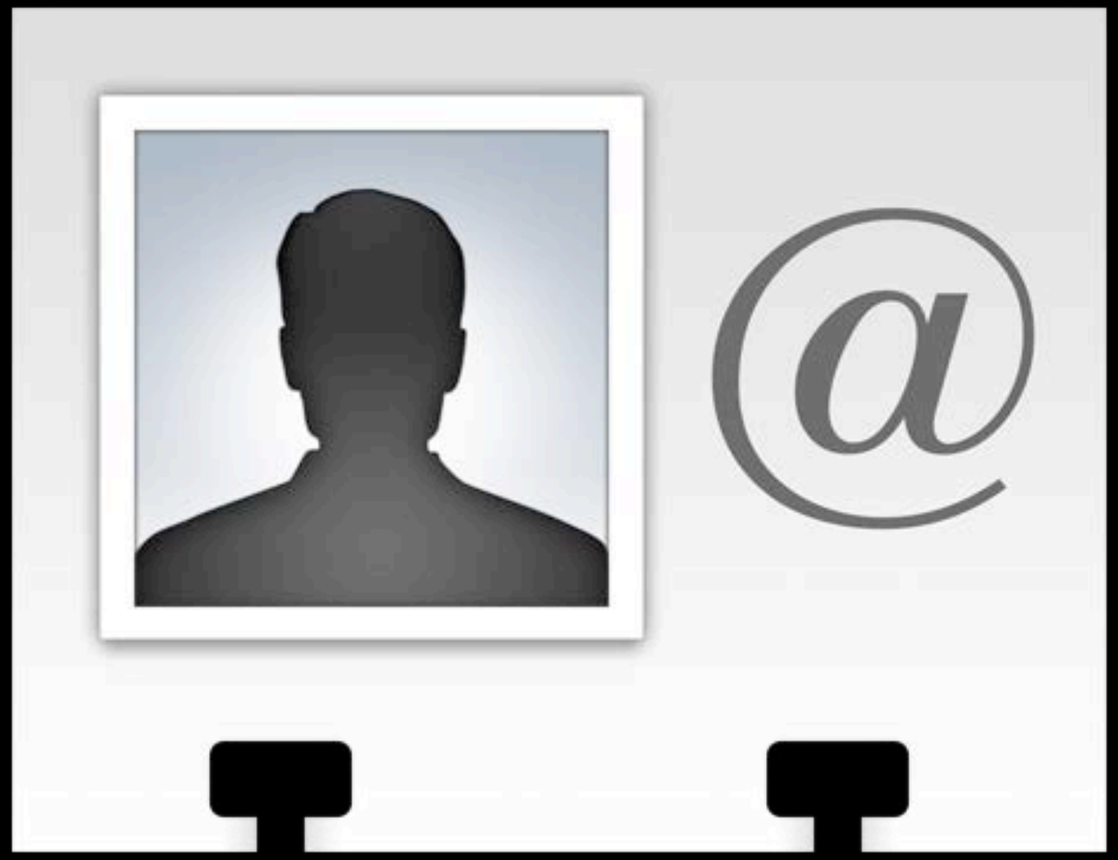


Performance Improvements

Sending data

115 BPM



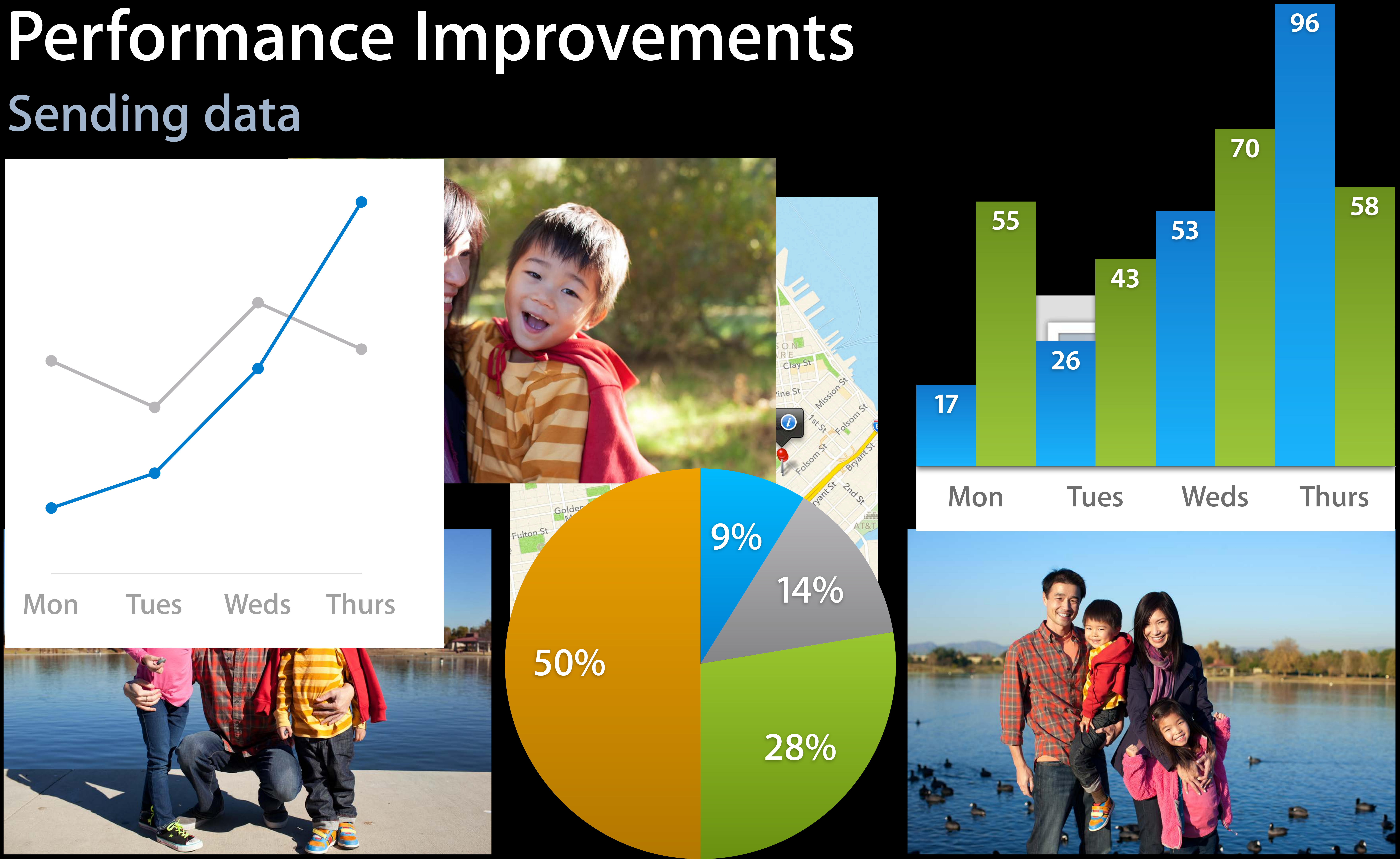


Performance Improvements

Sending data

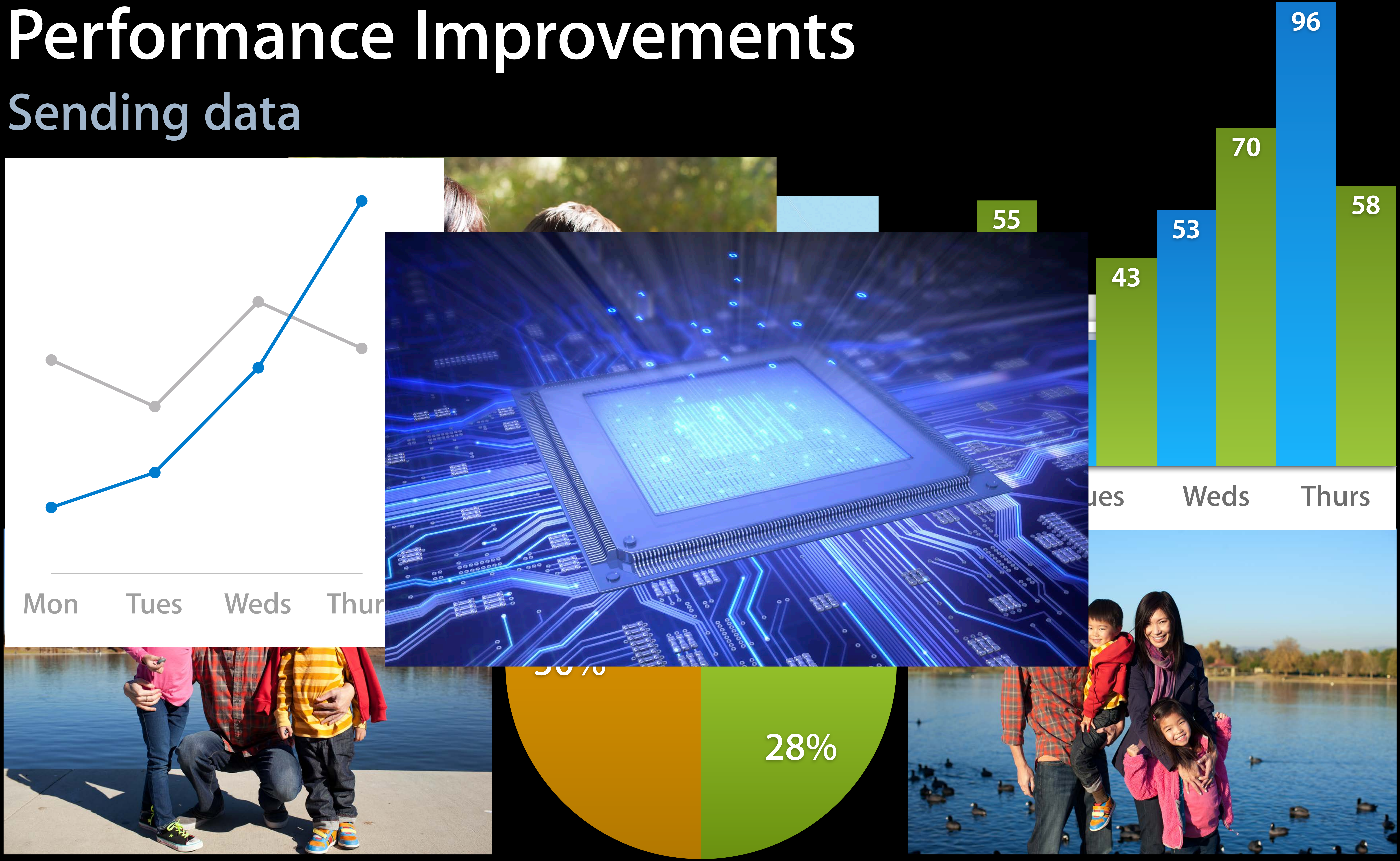
Performance Improvements

Sending data



Performance Improvements

Sending data



mm
ll
kk
ii
hh
gg
ff
ee
dd
ll
kk
ii
hh
gg
ff
ee
dd
cc
bb
mm
hh
gg

Performance Improvements

Sending data

Performance Improvements

Sending data

- Support MTU exchange request

Performance Improvements

Sending data

- Support MTU exchange request
- Maximum amount of data per PDU

Performance Improvements

Sending data

- Support MTU exchange request
- Maximum amount of data per PDU
- Send more data at a time

Performance Improvements

Sending data

Performance Improvements

Sending data

Default MTU

23 bytes

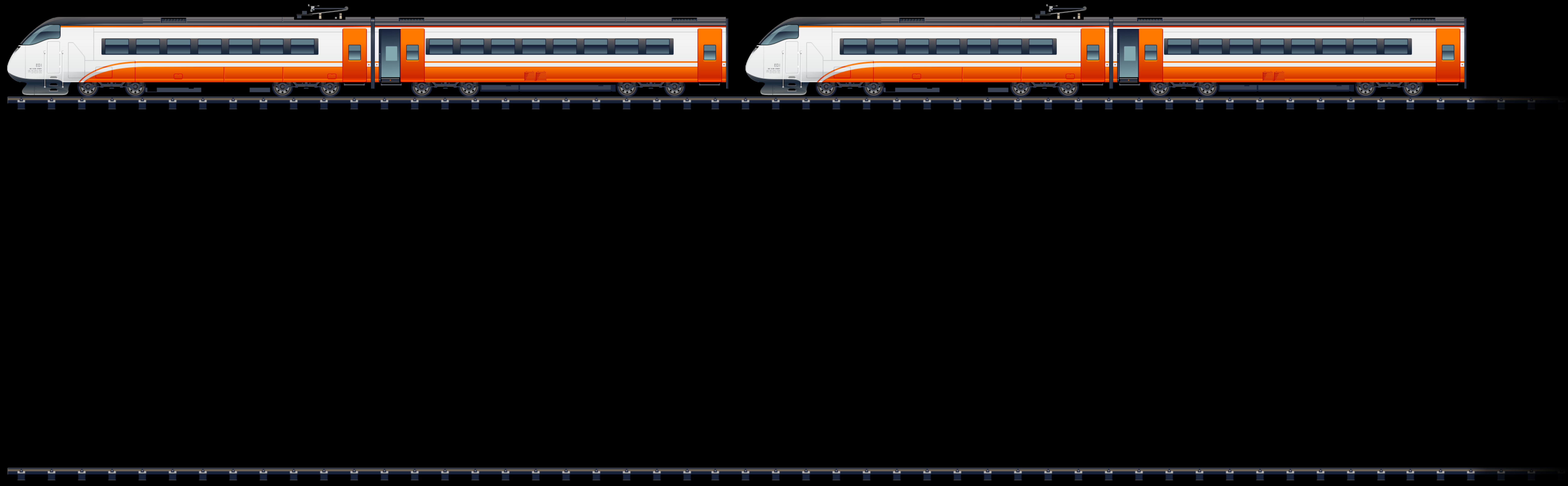
Performance Improvements

Sending data

Default MTU
23 bytes

Performance Improvements

Sending data



Default MTU
23 bytes

Increased MTU
??? bytes

Performance Improvements

Sending data

Default MTU
23 bytes

Increased MTU
??? bytes

Performance Improvements

Sending data

Performance Improvements

Sending data

- When central, ask for larger MTU

Performance Improvements

Sending data

- When central, ask for larger MTU
- Up to 20% increase in throughput

Performance Improvements

Sending data

- When central, ask for larger MTU
- Up to 20% increase in throughput
- Free!

Performance Improvements

Performing long-term actions

Performance Improvements

Performing long-term actions

Performing Long-Term Actions

Living in a multitasking world

Performing Long-Term Actions

Living in a multitasking world

- Backgrounding modes

Performing Long-Term Actions

Living in a multitasking world

- Backgrounding modes
    - App communicates using CoreBluetooth

Performing Long-Term Actions

Living in a multitasking world

- Backgrounding modes
  - App communicates using CoreBluetooth
  - App shares data using CoreBluetooth

Performing Long-Term Actions

Living in a multitasking world

- Backgrounding modes
  - App communicates using CoreBluetooth
  - App shares data using CoreBluetooth
- Background applications can be terminated by system

Performing Long-Term Actions

Living in a multitasking world

- Backgrounding modes
  - App communicates using CoreBluetooth
  - App shares data using CoreBluetooth
- Background applications can be terminated by system
- Some use-cases take hours

CONTINUE?

YES ▶ NO

CONTINUE?

YES ▶ NO

CONTINUE?

YES ▶ NO

WWDC2013

CONTINUE?

[✓ YES] NO

Performing Long-term Actions

Our solution

Performing Long-term Actions

Our solution

- System watches application state

Performing Long-term Actions

Our solution

- System watches application state
- When application is terminated…

Performing Long-term Actions

Our solution

- System watches application state
- When application is terminated…
    - If cause is memory pressure

Performing Long-term Actions

Our solution

- System watches application state
- When application is terminated…
  - If cause is memory pressure
  - If application is performing long-term action(s)

Performing Long-term Actions

Our solution

- System watches application state
- When application is terminated…
    - If cause is memory pressure
    - If application is performing long-term action(s)
- System acts as application proxy

Performing Long-term Actions

Our solution

- System watches application state
- When application is terminated…
  - If cause is memory pressure
  - If application is performing long-term action(s)
- System acts as application proxy
- When needed, application is re-launched

State Preservation and Restoration

State Preservation and Restoration

- Opt-in

State Preservation and Restoration

- Opt-in
- Supported by CBCentralManager and CBPeripheralManager

State Preservation and Restoration

- Opt-in
- Supported by CBCentralManager and CBPeripheralManager
- Minimal implementation
  - Provide unique “identifier” for manager
  - Implement new delegate method

State Preservation and Restoration

A picture is worth a thousand words

State Preservation and Restoration

A picture is worth a thousand words

- Snapshot taken before termination

State Preservation and Restoration

A picture is worth a thousand words

- Snapshot taken before termination
- `CBCentralManager`

State Preservation and Restoration

A picture is worth a thousand words

- Snapshot taken before termination
- `CBCentralManager`
    - Scanning state

State Preservation and Restoration

A picture is worth a thousand words

- Snapshot taken before termination
- `CBCentralManager`
  - Scanning state
  - Pending/active connections

State Preservation and Restoration

A picture is worth a thousand words

- Snapshot taken before termination
- `CBCentralManager`
    - Scanning state
    - Pending/active connections
    - Peripheral subscriptions

State Preservation and Restoration

A picture is worth a thousand words

- Snapshot taken before termination
- `CBCentralManager`
  - Scanning state
  - Pending/active connections
  - Peripheral subscriptions
- `CBPeripheralManager`

State Preservation and Restoration

A picture is worth a thousand words

- Snapshot taken before termination
- `CBCentralManager`
  - Scanning state
  - Pending/active connections
  - Peripheral subscriptions
- `CBPeripheralManager`
  - Advertising state

State Preservation and Restoration

A picture is worth a thousand words

- Snapshot taken before termination
- `CBCentralManager`
  - Scanning state
  - Pending/active connections
  - Peripheral subscriptions
- `CBPeripheralManager`
  - Advertising state
  - Published services

State Preservation and Restoration

A picture is worth a thousand words

- Snapshot taken before termination
- `CBCentralManager`
  - Scanning state
  - Pending/active connections
  - Peripheral subscriptions
- `CBPeripheralManager`
  - Advertising state
  - Published services
  - Central subscriptions

State Preservation and Restoration

Back from the dead

State Preservation and Restoration

Back from the dead

State Preservation and Restoration

Back from the dead

- Events that system can’t handle trigger application re-launch

State Preservation and Restoration

Back from the dead

- Events that system can’t handle trigger application re-launch
    - Peripheral connects, central subscribes, notification received, etc.

State Preservation and Restoration

Back from the dead

- Events that system can’t handle trigger application re-launch
    - Peripheral connects, central subscribes, notification received, etc.
- Application re-launched into background, running

State Preservation and Restoration

Back from the dead

- Events that system can’t handle trigger application re-launch
  - Peripheral connects, central subscribes, notification received, etc.
- Application re-launched into background, running
  - Re-instantiates appropriate manager object(s)

State Preservation and Restoration

Back from the dead

- Events that system can’t handle trigger application re-launch
  - Peripheral connects, central subscribes, notification received, etc.
- Application re-launched into background, running
  - Re-instantiates appropriate manager object(s)
  - Delegate callback provides all preserved state

State Preservation and Restoration

Back from the dead

- Events that system can’t handle trigger application re-launch
    - Peripheral connects, central subscribes, notification received, etc.
- Application re-launched into background, running
    - Re-instantiates appropriate manager object(s)
    - Delegate callback provides all preserved state
    - Power on event

State Preservation and Restoration

Back from the dead

- Events that system can’t handle trigger application re-launch
  - Peripheral connects, central subscribes, notification received, etc.
- Application re-launched into background, running
  - Re-instantiates appropriate manager object(s)
  - Delegate callback provides all preserved state
  - Power on event
  - Delegate callback for triggering event

Demo

Adding State Preservation and Restoration Support

Jason Conn
Code Monkey & Radio Sponge

Built-in Services

Bluetooth Low Energy graduates

Renaud Lienhart
Keeper of the Code & General Curmudgeon

Built-in Services

GATT Client

Built-in Services

GATT Client

- HID Over GATT Profile
  - HID, Battery, Device Information services

Built-in Services

GATT Client

- HID Over GATT Profile
  - HID, Battery, Device Information services
- Works just like Bluetooth Classic
  - Managed from Bluetooth Settings
  - iOS automatically reconnects paired peripherals

Built-in Services

GATT Server

Built-in Services

GATT Server

- Battery Service

Built-in Services

GATT Server

- Battery Service
- Current Time Service
    - Accurate time and date
    - Time zone information

Built-in Services

GATT Server

- Battery Service
- Current Time Service
  - Accurate time and date
  - Time zone information

- One more thing…

Built-in Services

Notifications—the problems

Built-in Services

Notifications—the problems

- Message Access Profile (MAP)

Built-in Services

Notifications—the problems

- Message Access Profile (MAP)
  - Developed for an automotive usage

Built-in Services

Notifications—the problems

- Message Access Profile (MAP)
  - Developed for an automotive usage
  - Very constrained: SMS, MMS, Email

Built-in Services

Notifications—the problems

- Message Access Profile (MAP)
  - Developed for an automotive usage
  - Very constrained: SMS, MMS, Email
- Alert Notification Service

Built-in Services

Notifications—the problems

- Message Access Profile (MAP)
    - Developed for an automotive usage
    - Very constrained: SMS, MMS, Email
- Alert Notification Service
    - Very limited

Built-in Services

Notifications—the problems

- Message Access Profile (MAP)
  - Developed for an automotive usage
  - Very constrained: SMS, MMS, Email
- Alert Notification Service
  - Very limited
- Custom app tailored to a specific accessory

Built-in Services

Notifications—the problems

- Message Access Profile (MAP)
  - Developed for an automotive usage
  - Very constrained: SMS, MMS, Email
- Alert Notification Service
  - Very limited
- Custom app tailored to a specific accessory
  - Heavyweight

Built-in Services

Notifications—the problems

- Message Access Profile (MAP)
  - Developed for an automotive usage
  - Very constrained: SMS, MMS, Email
- Alert Notification Service
  - Very limited
- Custom app tailored to a specific accessory
  - Heavyweight
  - Data limited to what the sandbox allows

Built-in Services

Notifications—our solution

Built-in Services

Notifications—our solution

- Apple Notification Center Service

Built-in Services

Notifications—our solution

- Apple Notification Center Service
    - Apple-specific

Built-in Services

Notifications—our solution

- Apple Notification Center Service
    - Apple-specific
    - Notification about any events on your phone

Built-in Services

Notifications—our solution

- Apple Notification Center Service
  - Apple-specific
  - Notification about any events on your phone
    - Incoming and Missed calls, Voicemails

Built-in Services

Notifications—our solution

- Apple Notification Center Service
    - Apple-specific
    - Notification about any events on your phone
        - Incoming and Missed calls, Voicemails
        - Instant messages, Emails

Built-in Services

Notifications—our solution

- Apple Notification Center Service
    - Apple-specific
    - Notification about any events on your phone
        - Incoming and Missed calls, Voicemails
        - Instant messages, Emails
        - Calendar alerts

Built-in Services

Notifications—our solution

- Apple Notification Center Service
    - Apple-specific
    - Notification about any events on your phone
        - Incoming and Missed calls, Voicemails
        - Instant messages, Emails
        - Calendar alerts
        - App notifications

Built-in Services

Notifications—our solution

- Apple Notification Center Service
    - Apple-specific
    - Notification about any events on your phone
        - Incoming and Missed calls, Voicemails
        - Instant messages, Emails
        - Calendar alerts
        - App notifications
    - System automatically reconnects

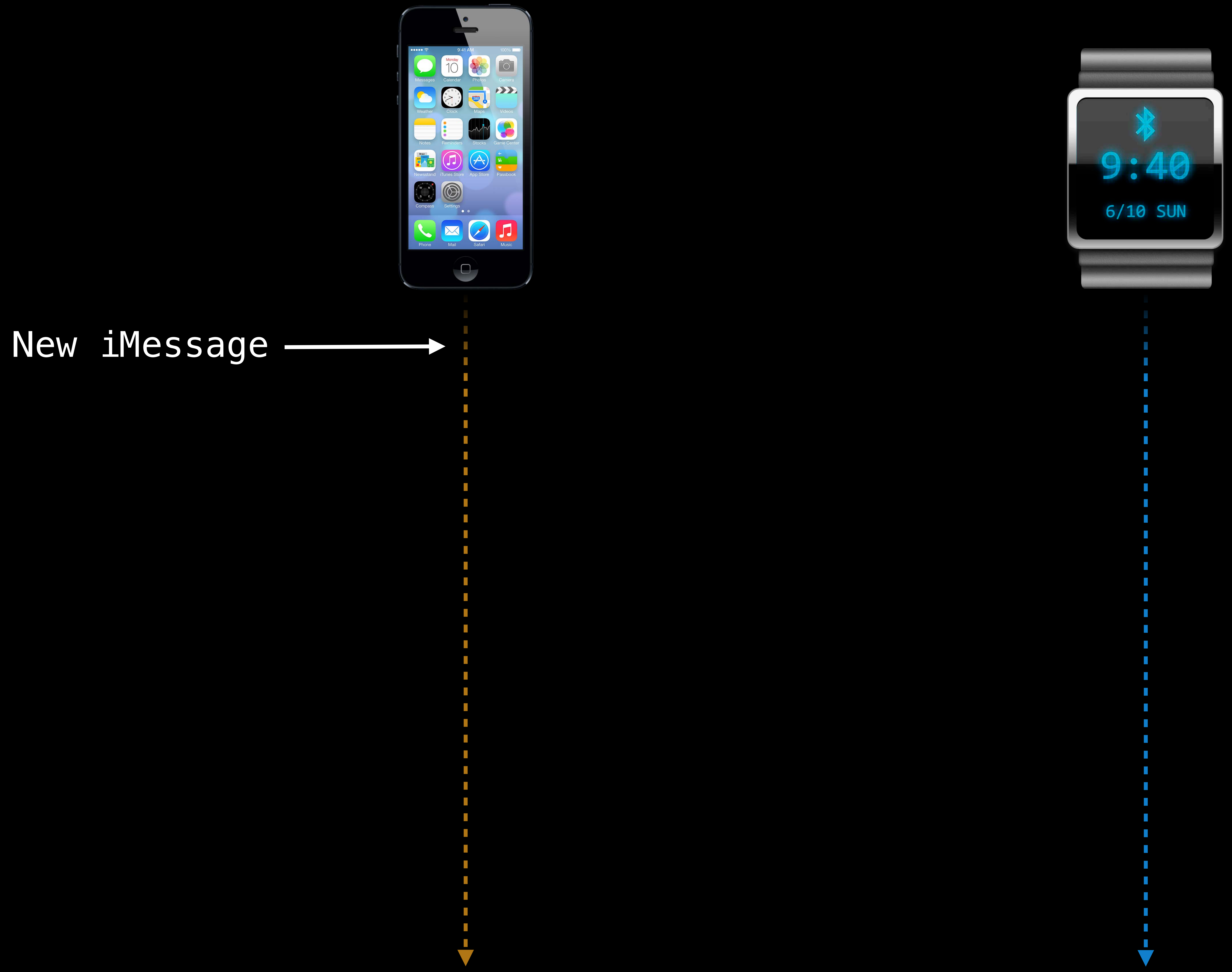
Built-in Services

Notifications—our solution

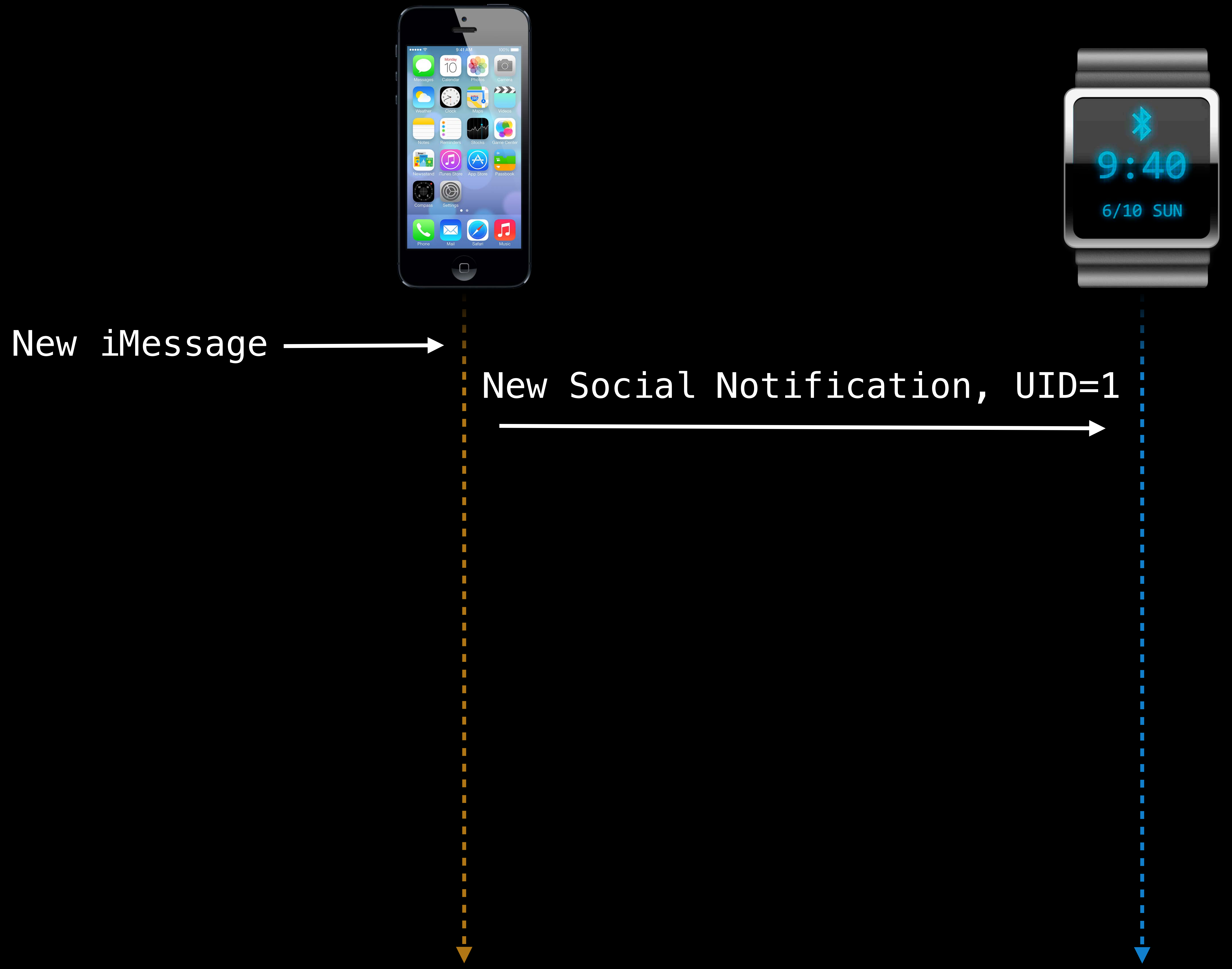
- Apple Notification Center Service
  - Apple-specific
  - Notification about any events on your phone
    - Incoming and Missed calls, Voicemails
    - Instant messages, Emails
    - Calendar alerts
    - App notifications
  - System automatically reconnects
  - Detailed specification posted on the developer portal soon

Built-in Services

Apple Notification Center Service

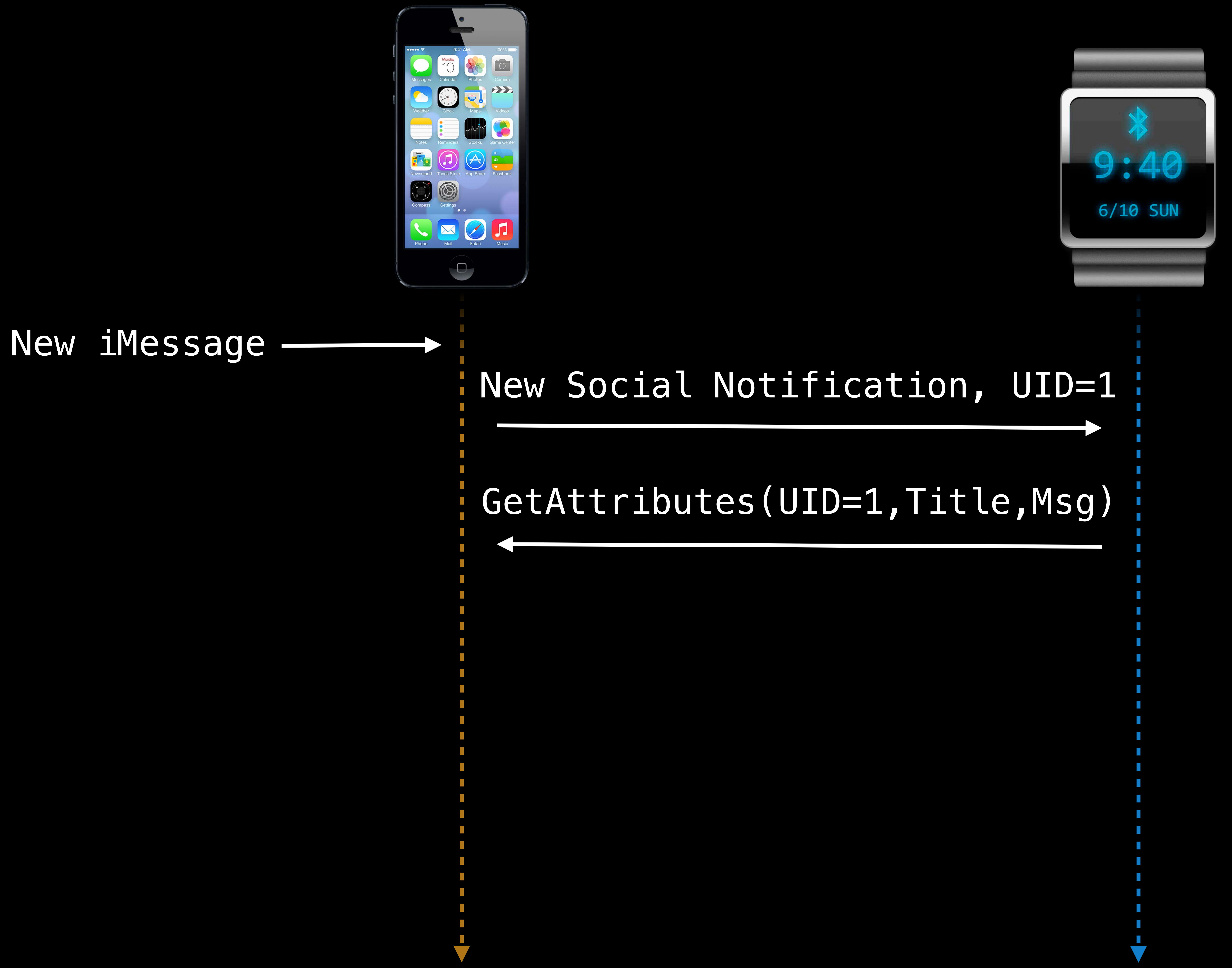


New iMessage



New iMessage

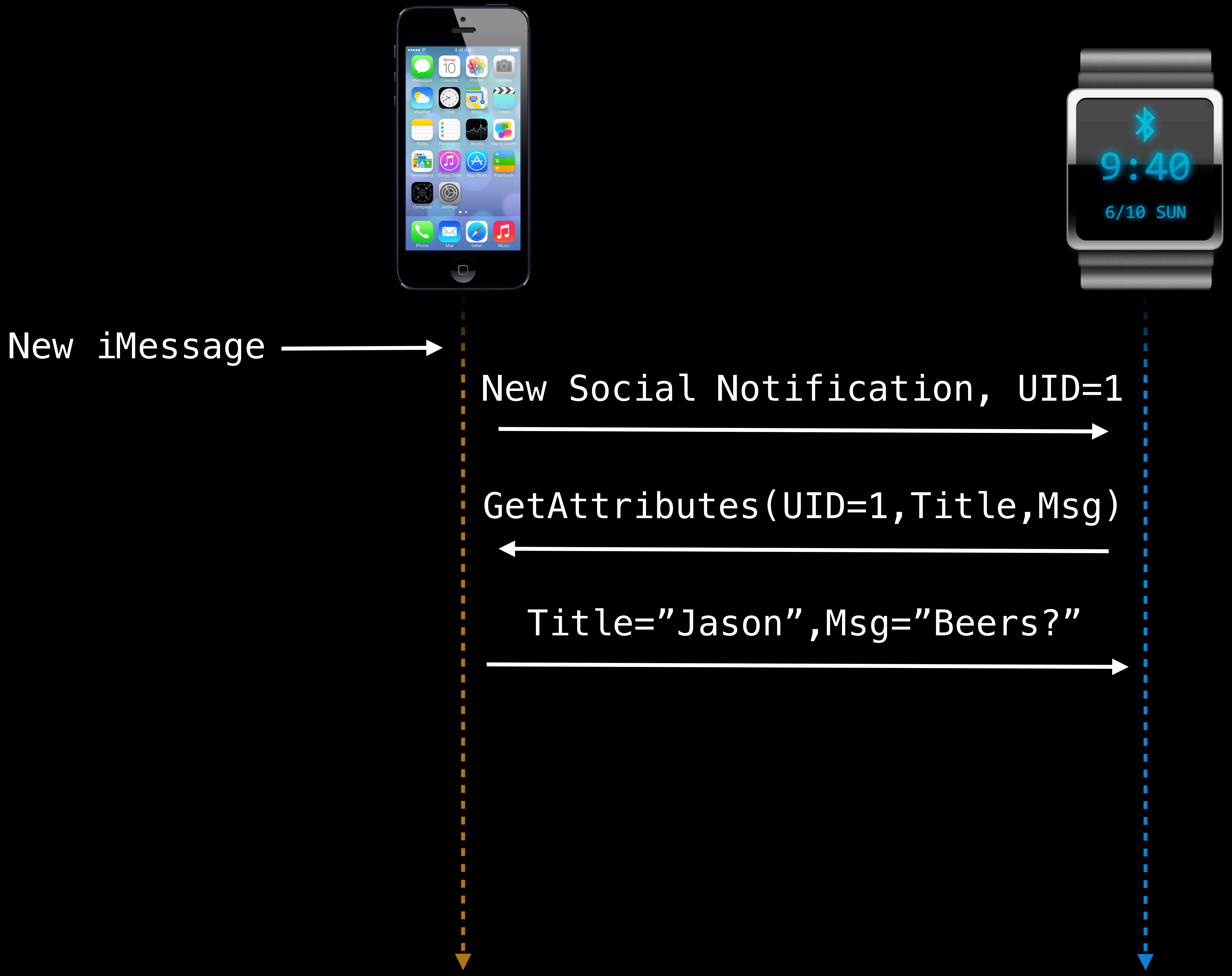
New Social Notification, UID=1



New iMessage

New Social Notification, UID=1

GetAttributes(UID=1,Title,Msg)

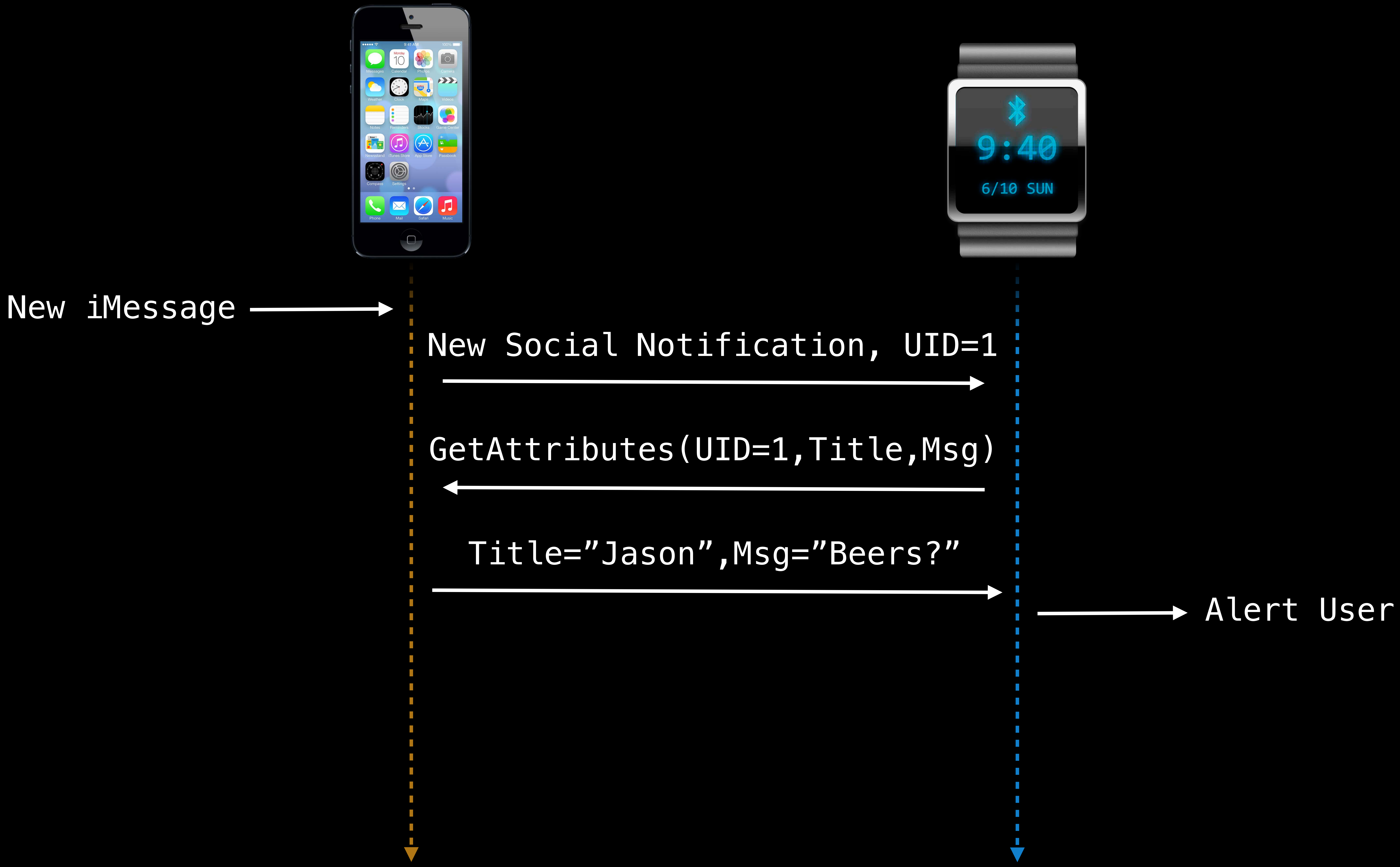


New iMessage

New Social Notification, UID=1

GetAttributes(UID=1,Title,Msg)

Title=”Jason”,Msg=”Beers?”



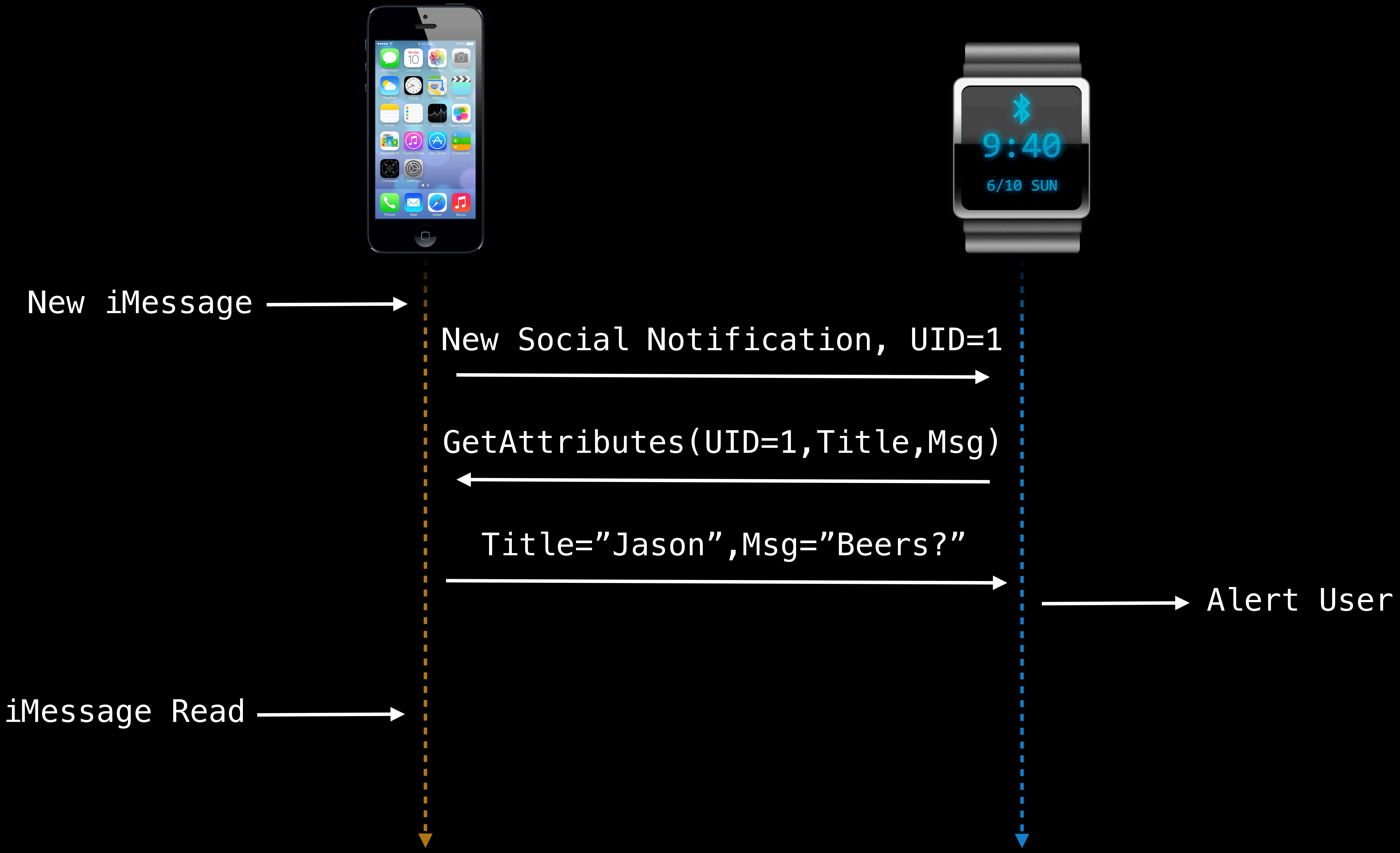
New iMessage

New Social Notification, UID=1

GetAttributes(UID=1,Title,Msg)

Title=”Jason”,Msg=”Beers?”

Alert User



New iMessage

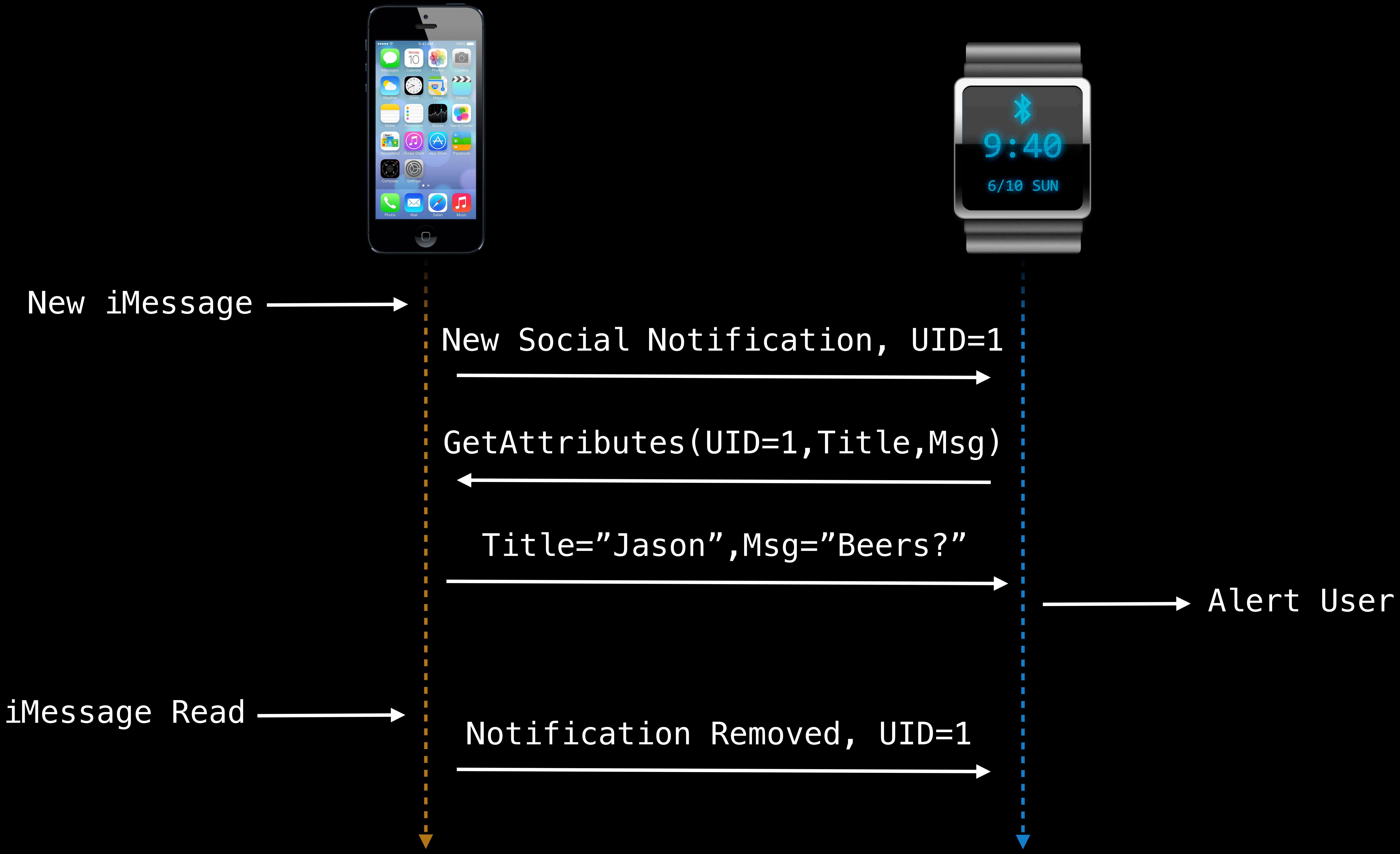
New Social Notification, UID=1

GetAttributes(UID=1,Title,Msg)

Title=”Jason”,Msg=”Beers?”

Alert User

iMessage Read



New iMessage

New Social Notification, UID=1

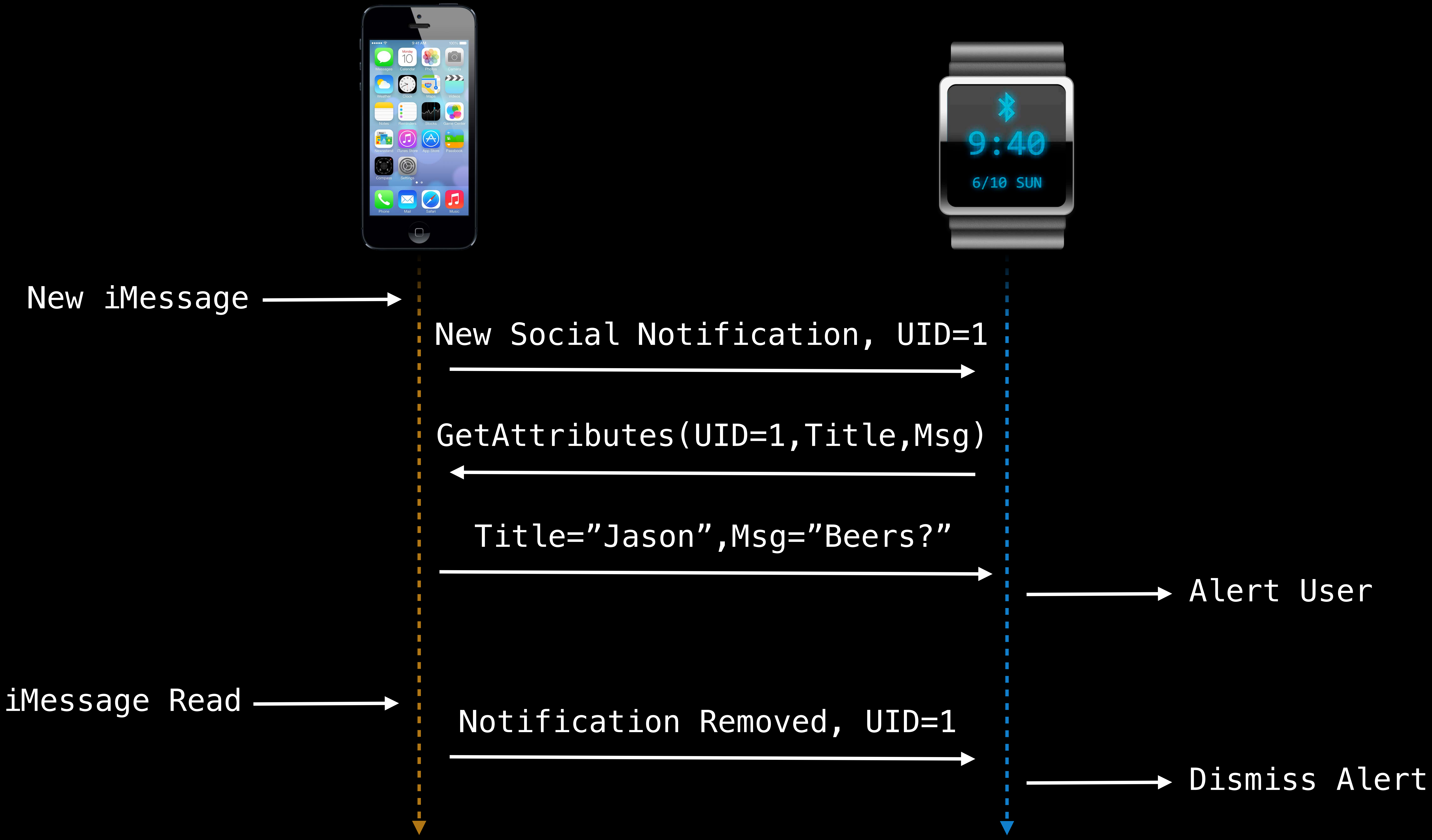
GetAttributes(UID=1,Title,Msg)

Title=”Jason”,Msg=”Beers?”

Alert User

iMessage Read

Notification Removed, UID=1



New iMessage

New Social Notification, UID=1

GetAttributes(UID=1,Title,Msg)

Title=”Jason”,Msg=”Beers?”

Alert User

iMessage Read

Notification Removed, UID=1

Dismiss Alert

Tips and Best Practices

Tips and Best Practices

- Core Bluetooth needs to know if you intend to use CBPeripherals—keep a reference to them

Tips and Best Practices

- Core Bluetooth needs to know if you intend to use CBPeripherals—keep a reference to them
- Scanning and connection requests do not time out

Tips and Best Practices

- Core Bluetooth needs to know if you intend to use CBPeripherals—keep a reference to them
- Scanning and connection requests do not time out
- CBPeripheral and CBCentral conform to NSCopying and can be used as dictionary keys

Tips and Best Practices

- Core Bluetooth needs to know if you intend to use CBPeripherals—keep a reference to them
- Scanning and connection requests do not time out
- CBPeripheral and CBCentral conform to NSCopying and can be used as dictionary keys
- Do not touch Client Configuration Characteristic Descriptors directly

Tips and Best Practices

- Core Bluetooth needs to know if you intend to use CBPeripherals—keep a reference to them
- Scanning and connection requests do not time out
- CBPeripheral and CBCentral conform to NSCopying and can be used as dictionary keys
- Do not touch Client Configuration Characteristic Descriptors directly
- Do not game the background mechanisms

Apple Guidelines

Bluetooth best practices

http://developer.apple.com/hardwaredrivers/
BluetoothDesignGuidelines.pdf

Apple Guidelines

Core Bluetooth Programming Guide

Finally!

More Information

Craig Keithley
MFi & I/O Technology Evangelist
keithley@apple.com

Stephen Chick
iPhone Evangelism
chick@apple.com

Developer Programs
MFi Program
http://developer.apple.com/mfi/

More Information

Bluetooth Accessory Design Guidelines
http://developer.apple.com/hardwaredrivers/BluetoothDesignGuidelines.pdf

Reporting Bugs
http://bugreport.apple.com

Apple Developer Forums
https://devforums.apple.com/community/ios/core/cbt
https://devforums.apple.com/community/mac/coreos/cbt

Bluetooth Developer Site
http://developer.bluetooth.org

Related Sessions

Designing Accessories for iOS and OS X	Nob Hill Tuesday 10:15AM	🟦
What’s New in Core Location	Presidio Thursday 11:30AM	🟩

Labs

iOS and OS X Accessories Lab	Core OS Lab A Tuesday 11:30AM
iOS and OS X Accessories Lab	Core OS Lab B Thursday 9:00AM

Finder File Edit View Go Window Help
Mon 9:41 AM
MacBook Air

Health Care

Sports/Fitness

Security

Automation

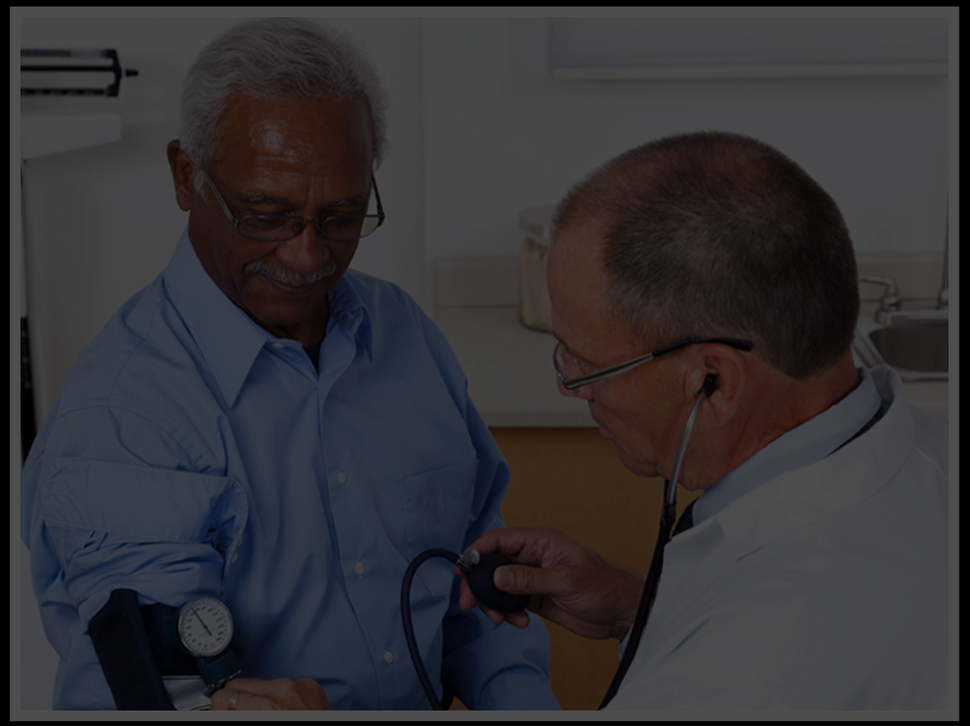
Toys

Pay Systems

Entertainment

Proximity

Connect the World

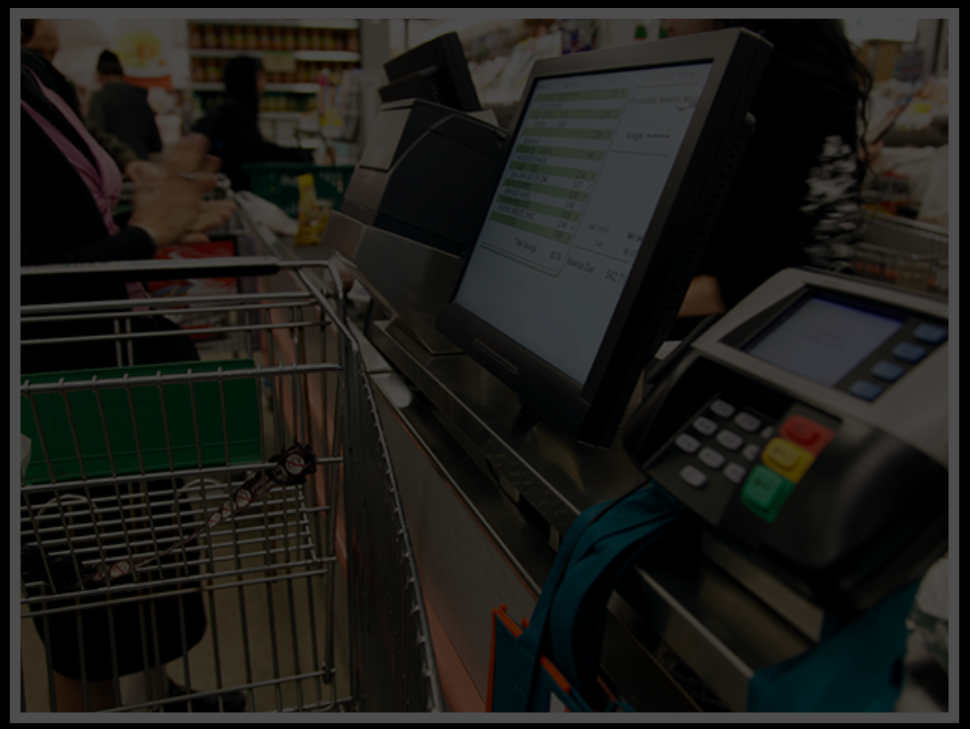

Health Care

Sports/Fitness

Security

Automation

Toys


Pay Systems

Entertainment

Proximity

WWDC2013