Engineering Privacy for Your Users

Session 709

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Julien Freudiger Privacy Engineering

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“People have entrusted us with their most personal information. We owe them nothing less than the best protections that we can possibly provide.”

Tim Cook
White House Cybersecurity Summit, February 2015

Great Apps Respect User Privacy

Transparency

Control

Consent

Security

Minimization

Use Limitation

Your Users + You + Privacy = 😀

Overview

Identifiers

Data Collection

Transparency and Control

Meaningful Choices

Building Privacy into Your App

Identifiers

😄 Know your users

😄 Know your users

☹️ Track everywhere

😄 Know your users

☹️ Track everywhere

🤓 Customize services

😄 Know your users

😕 Track everywhere

🤓 Customize services

😧 Creepy services

😄 Know your users

😕 Track everywhere

🤓 Customize services

😦 Creepy services

🤗 Prevent fraud

😄 Know your users

🤓 Customize services

🤗 Prevent fraud

☹️ Track everywhere

😦 Creepy services

😱 Collect everything

Identifiers Best Practices

Identifiers Best Practices

Short-lived

Identifiers Best Practices

Short-lived

Random

Identifiers Best Practices

Short-lived

Random

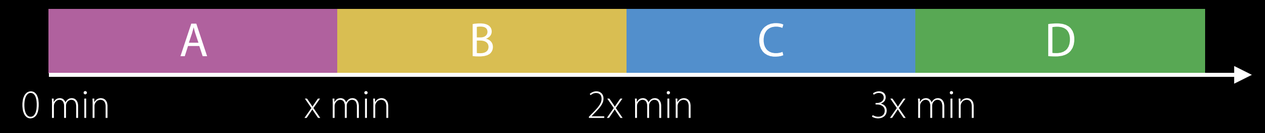
Anonymous

Examples

Examples

Favor short-lived identifiers

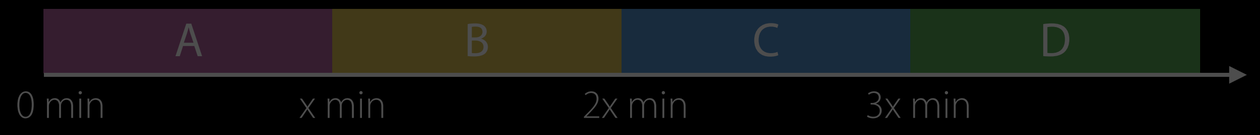
Spotlight, Maps



Examples

Favor short-lived identifiers

Spotlight, Maps



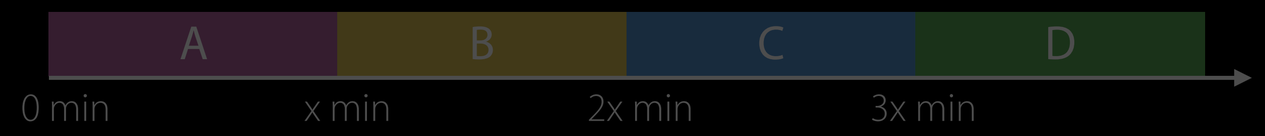
Make it easy to reset identifiers

Siri, News

Examples

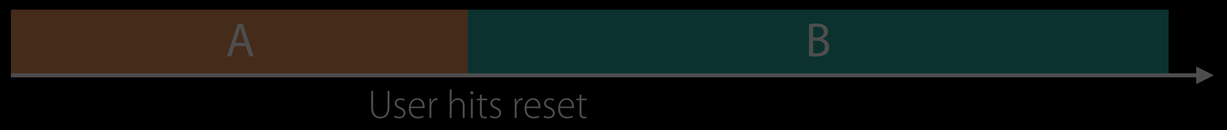
Favor short-lived identifiers

Spotlight, Maps



Make it easy to reset identifiers

Siri, News



Identify sessions, not users

Universally Unique Identifiers (UUID)

New unique identifier for each function call

```
let uuid = UUID()
```

Universally Unique Identifiers (UUID)

Example

Universally Unique Identifiers (UUID)

Example

Call 1 a275e7cc-1d37-4ee8-8861-15ab231e44d4

Universally Unique Identifiers (UUID)

Example

Call 1 a275e7cc-1d37-4ee8-8861-15ab231e44d4

Call 2 99968a76-c1af-4257-8351-a25e82887d4e

Universally Unique Identifiers (UUID)

Example

Call 1	a275e7cc-1d37-4ee8-8861-15ab231e44d4
Call 2	99968a76-c1af-4257-8351-a25e82887d4e
Call 3	2ce3a2cd-e430-47d0-a983-b445964c46ec

Vendor ID

Persisted by system to identify device to an app vendor

```
let identifierForVendor = current().identifierForVendor.uuidString
```

Vendor ID

Example

Vendor ID

Example

com.myCompany.app1 bd81cef8-c5b3-4413-846d-3df993c8f256

Vendor ID

Example

com.myCompany.app1	bd81cef8-c5b3-4413-846d-3df993c8f256
com.myCompany.app2	bd81cef8-c5b3-4413-846d-3df993c8f256

Vendor ID

Example

com.myCompany.app1	bd81cef8-c5b3-4413-846d-3df993c8f256
com.myCompany.app2	bd81cef8-c5b3-4413-846d-3df993c8f256
com.myOtherCompany.app1	94004a56-8849-46f7-9427-e6e91e6e060c

Advertising ID

Persisted by system for advertising purposes

```
let identifierForAdvertising = shared().advertisingIdentifier.uuidString
```

Advertising ID

Example

Advertising ID

Example

Device 595d16cc-c0fa-455f-8e30-d17c250139f6

Advertising ID

Example

Device 595d16cc-c0fa-455f-8e30-d17c250139f6

Device 595d16cc-c0fa-455f-8e30-d17c250139f6

Advertising ID

Example

Device	595d16cc-c0fa-455f-8e30-d17c250139f6

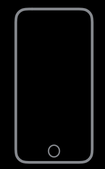
Device	595d16cc-c0fa-455f-8e30-d17c250139f6
Reset	2ce3a2cd-e430-47d0-a983-b445964c46ec

Identifiers' APIs

	Scope	Control	Backed Up	Restored Across Devices
UUID	App	Uninstall App	No	No
Vendor ID	Developer	Uninstall all Apps from same teamID	Yes	No
Advertising ID	Device	Reset Advertising ID	Yes	No

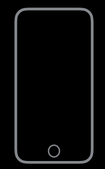
MAC Address Randomization

NEW



MAC Address Randomization

NEW



D1:8D:FC:AD:63:28

MAC Address Randomization

NEW

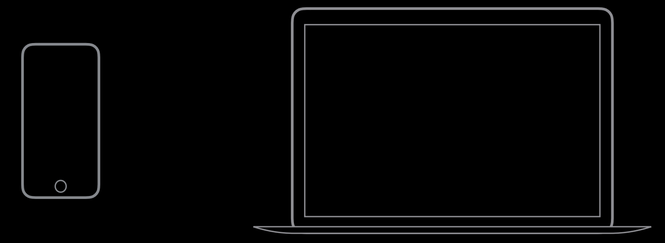
MAC Address Randomization

NEW

x min	2x min	3x min
72:F5:73:46:73:09	76:82:49:2B:E2:06	0C:2E:92:4E:71:B0

MAC Address Randomization

NEW



x min

72:F5:73:46:73:09

2x min

76:82:49:2B:E2:06

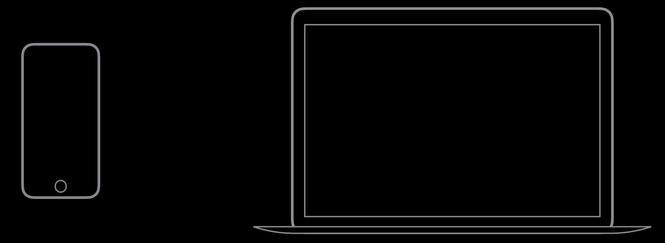
3x min

0C:2E:92:4E:71:B0

iOS and macOS

MAC Address Randomization

NEW



x min	2x min	3x min
72:F5:73:46:73:09	76:82:49:2B:E2:06	0C:2E:92:4E:71:B0

iOS and macOS

Real MAC address not always included in Wi-Fi scans

Message App Extensions

Users identified by random UUID

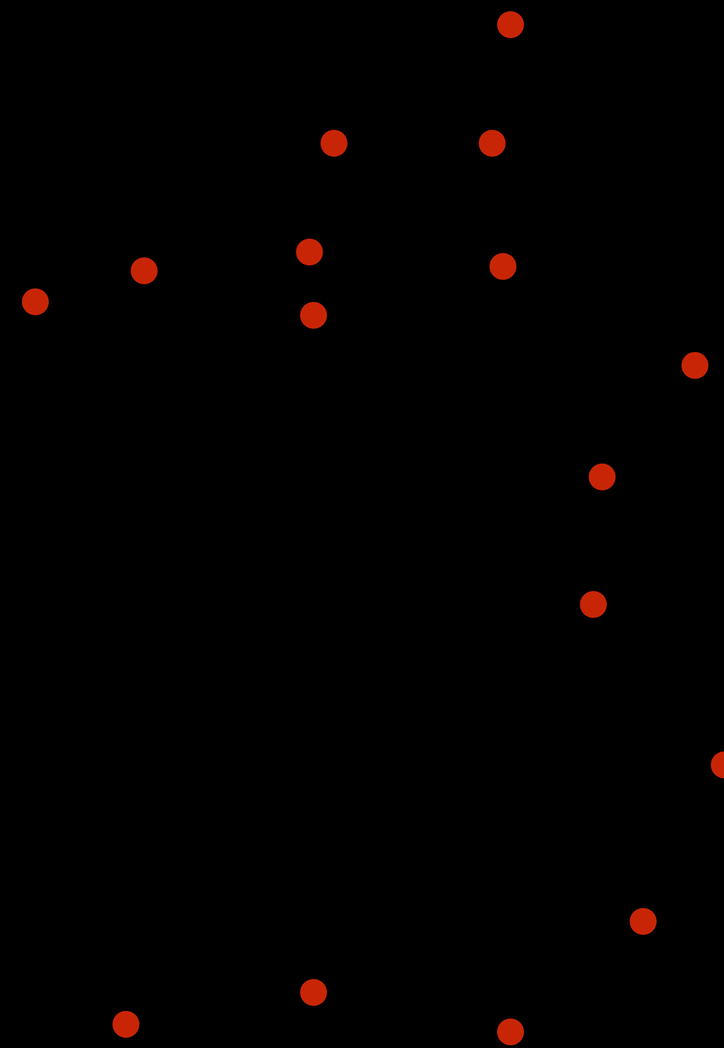
For each App extension

For each chat

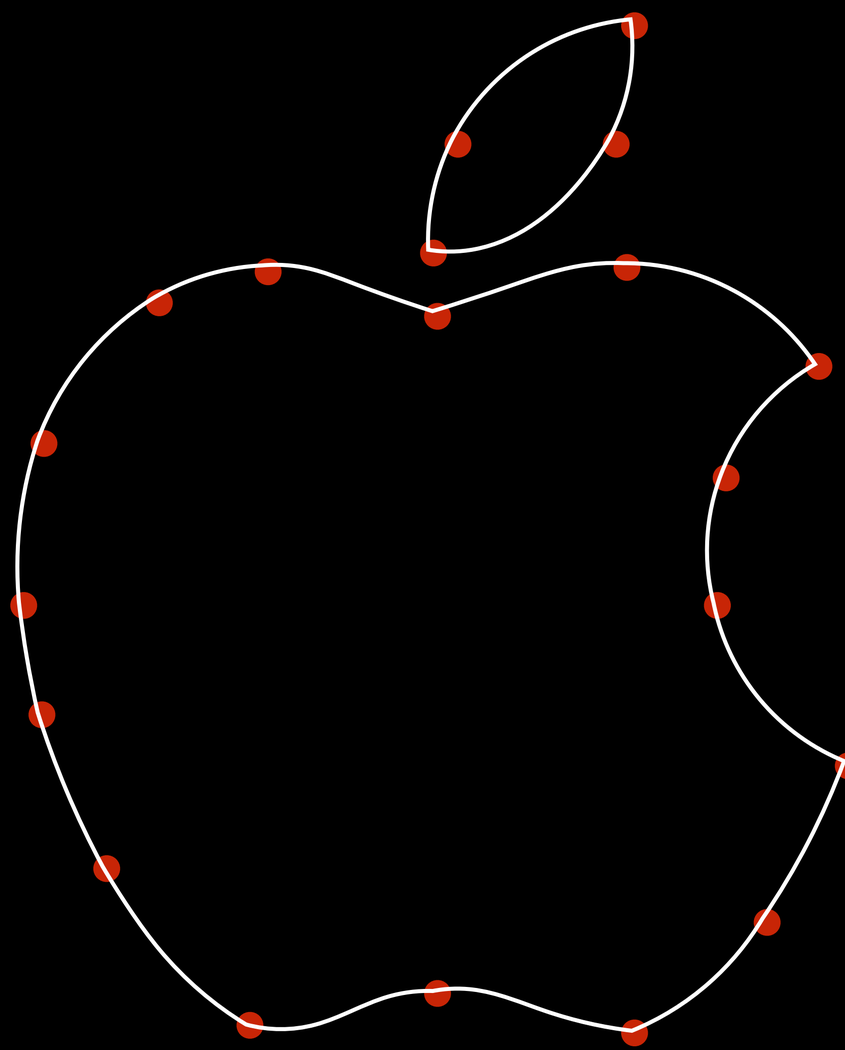
Messages Marina Tuesday 2:00PM

Implicit Identifiers

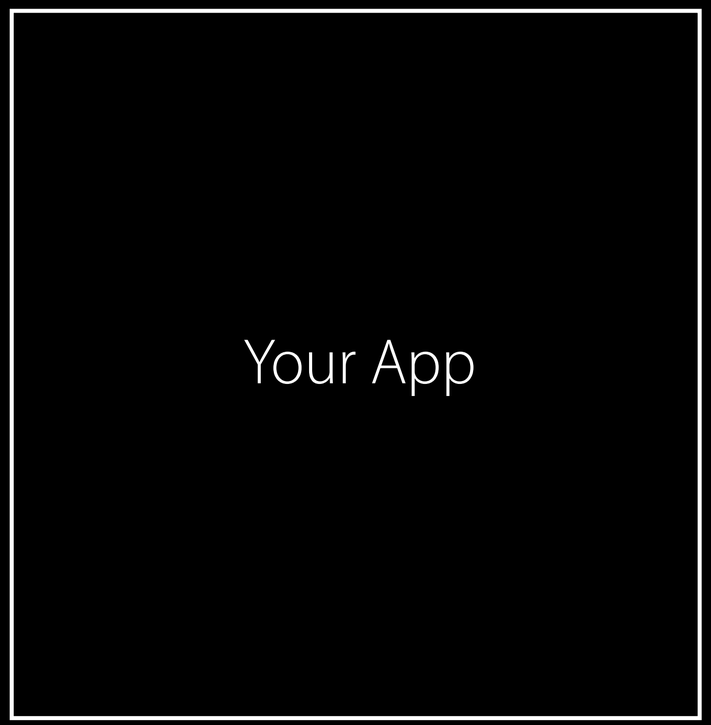
Implicit Identifiers



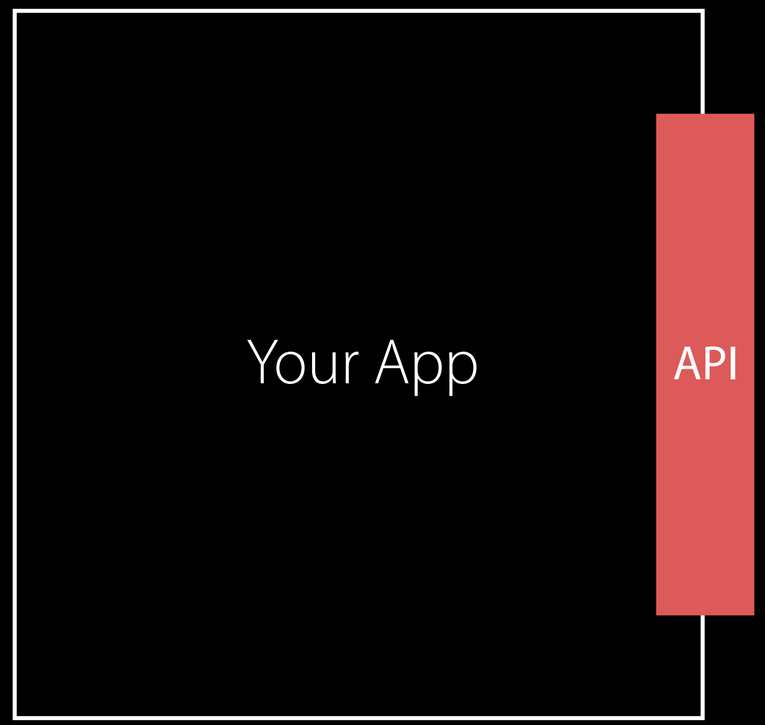
Implicit Identifiers



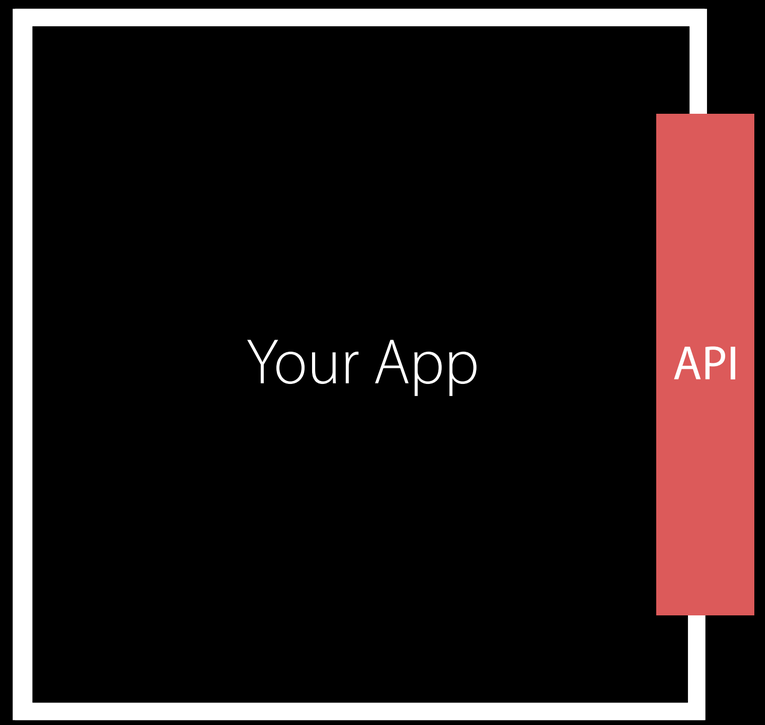
Sandboxing



Sandboxing



Sandboxing



What Does This Mean for You?

Identifiers

Favor short-term identifiers

Use OS-provided identifier APIs

Data Collection

Data Collection Best Practices

Bucket

Sample

Aggregate via Differential Privacy

Bucket

Only required detail

Bucket

Only required detail

How often does a given user open
in-app Settings on a given day?

Bucket

Only required detail

How often does a given user open
in-app Settings on a given day?

Bucket

Only required detail

How often does a given user open
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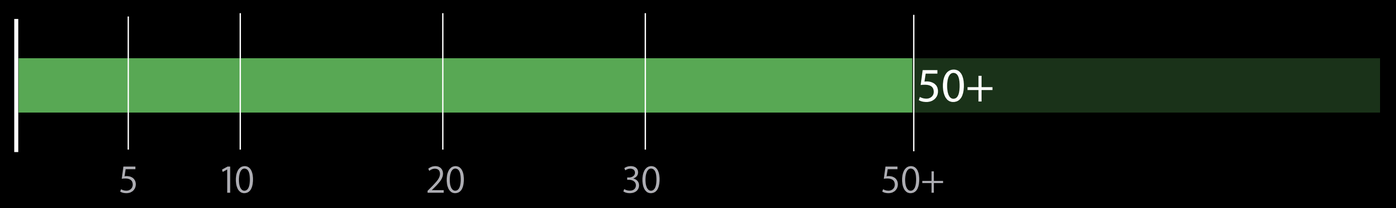

Sample

Only from subset of users

Sample

Only from subset of users

How often do my users open
in-app Settings on a given day?

Sample

Only from subset of users

How often do my users open
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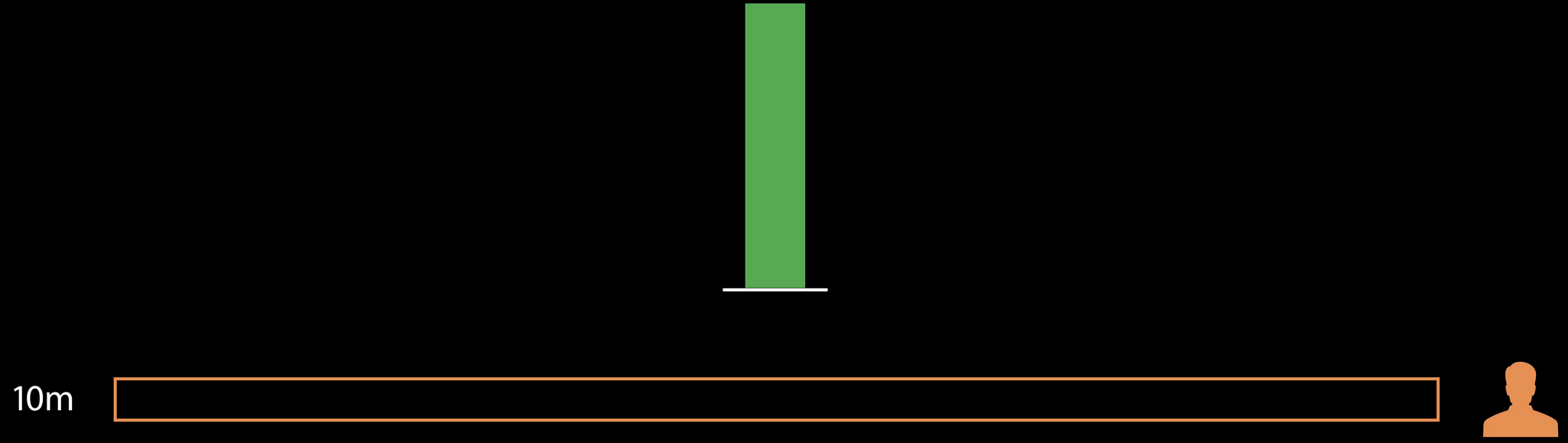

Sample

Only from subset of users

How often do my users open
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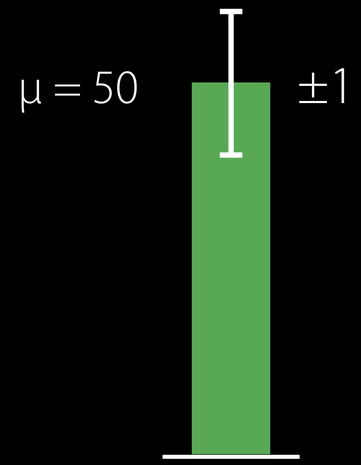
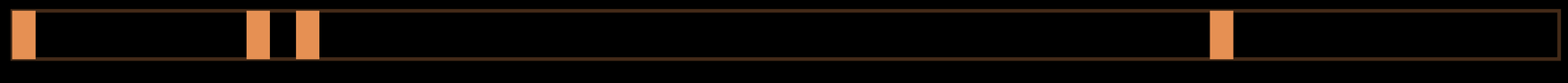


10k /10m



Sample

Only from subset of users

How often do my users open
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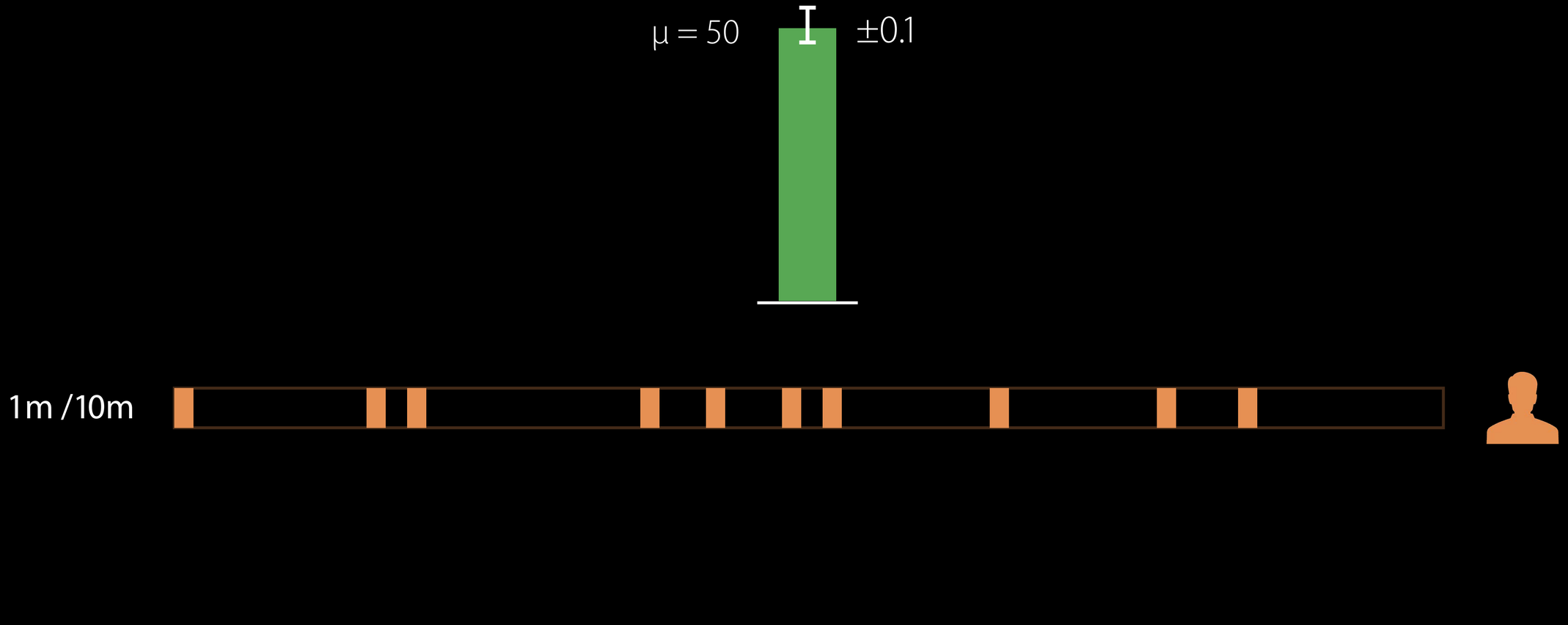


Aggregate via Differential Privacy

NEW

Aggregate via Differential Privacy

NEW

Learn from crowd while protecting individual privacy

Aggregate via Differential Privacy

NEW

Learn from crowd while protecting individual privacy

Strong mathematical guarantees

Aggregate via Differential Privacy

NEW

Learn from crowd while protecting individual privacy

Strong mathematical guarantees

iOS and macOS

$$\forall i \in [n], d \in S, \left| \ln \frac{\Pr[T_i \in T | d_i = d]}{\Pr[T_i \in T | d_i = \text{NULL}]} \right| \leq \epsilon$$

$$\left| \ln \frac{\Pr[A_{client}(d) = t]}{\Pr[A_{client}(\text{null}) = t]} \right| \leq \ln \left(\frac{e^\epsilon}{1 + e^\epsilon} \cdot \frac{1 + e^\epsilon}{1} \right) = \epsilon$$

$$\alpha = \frac{3k + 2c_\epsilon \sqrt{\ln(6mk/\beta)}}{\sqrt{n}} = O\left(\frac{\sqrt{\log(p/\beta)}}{\epsilon\sqrt{n}} \right)$$

$$\alpha = \frac{3k + c_\epsilon \sqrt{\ln(4mk/\beta)}}{\sqrt{n}} = O\left(\frac{\sqrt{\log(p/\beta)}}{\epsilon\sqrt{n}} \right)$$

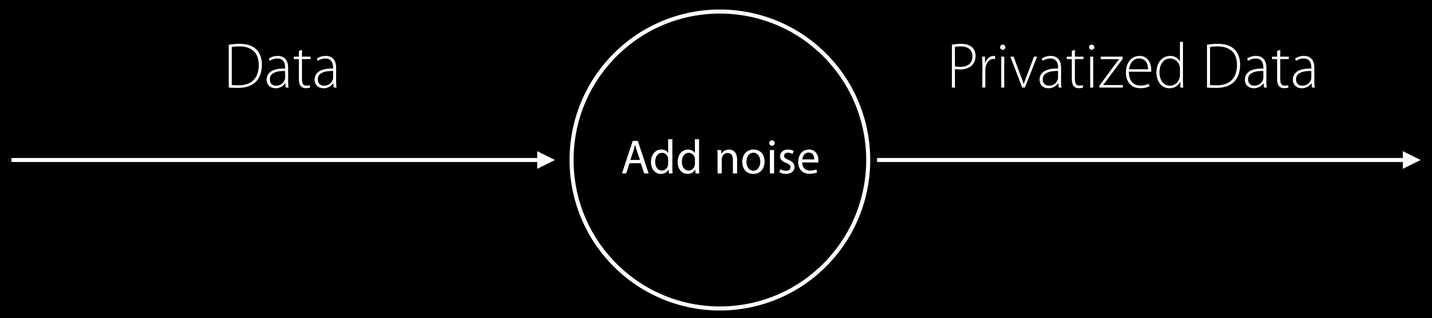
$$v_{\mathsf{priv}} = \left\{ \left(\frac{v[j] \cdot b[j] + 1}{2} \right), \forall j \in [m] \right\}$$

Idea

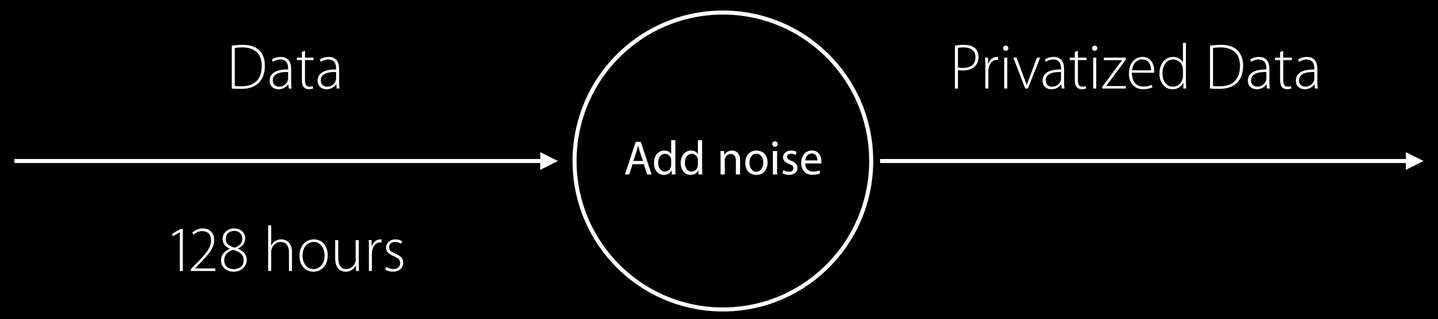
Data

Idea

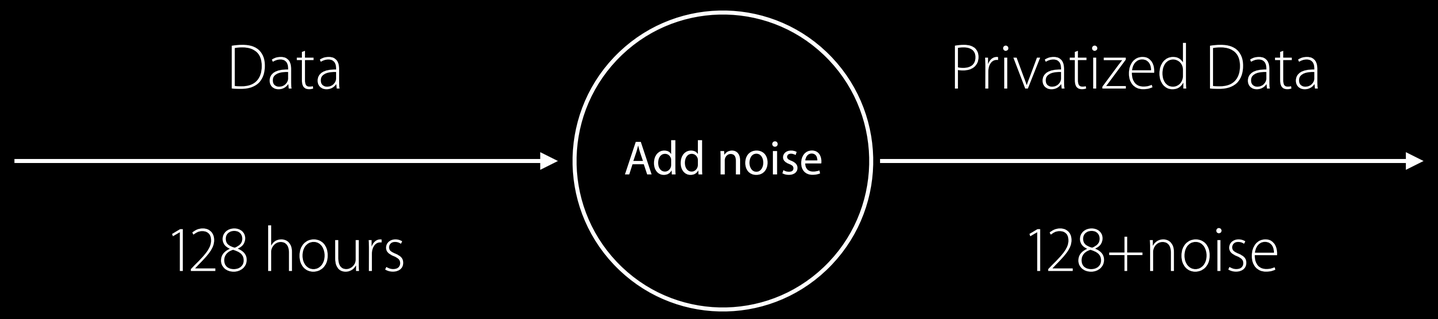
Idea



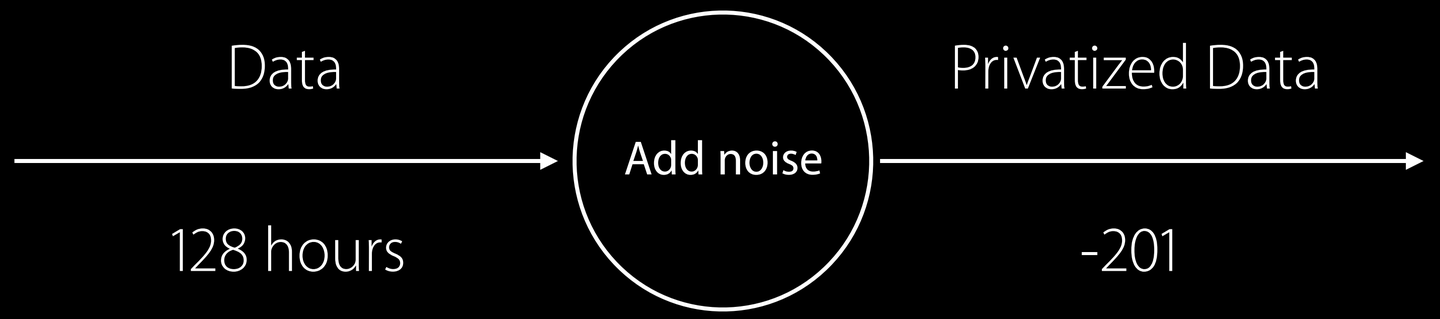
Idea



Idea



Idea



How Does Noise Work?

Original value 128

Compute projection

How Does Noise Work?

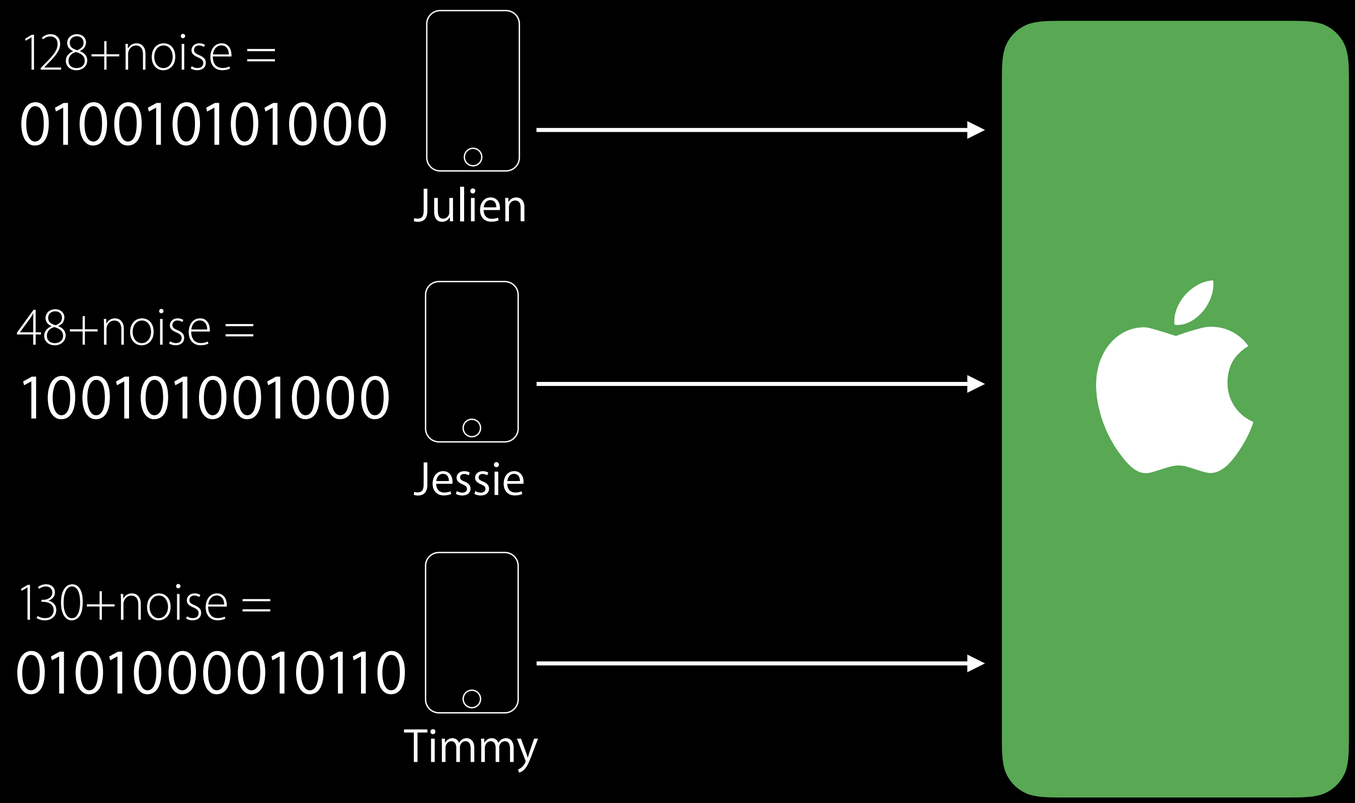
Original value 128

Compute projection 0000000001000000000

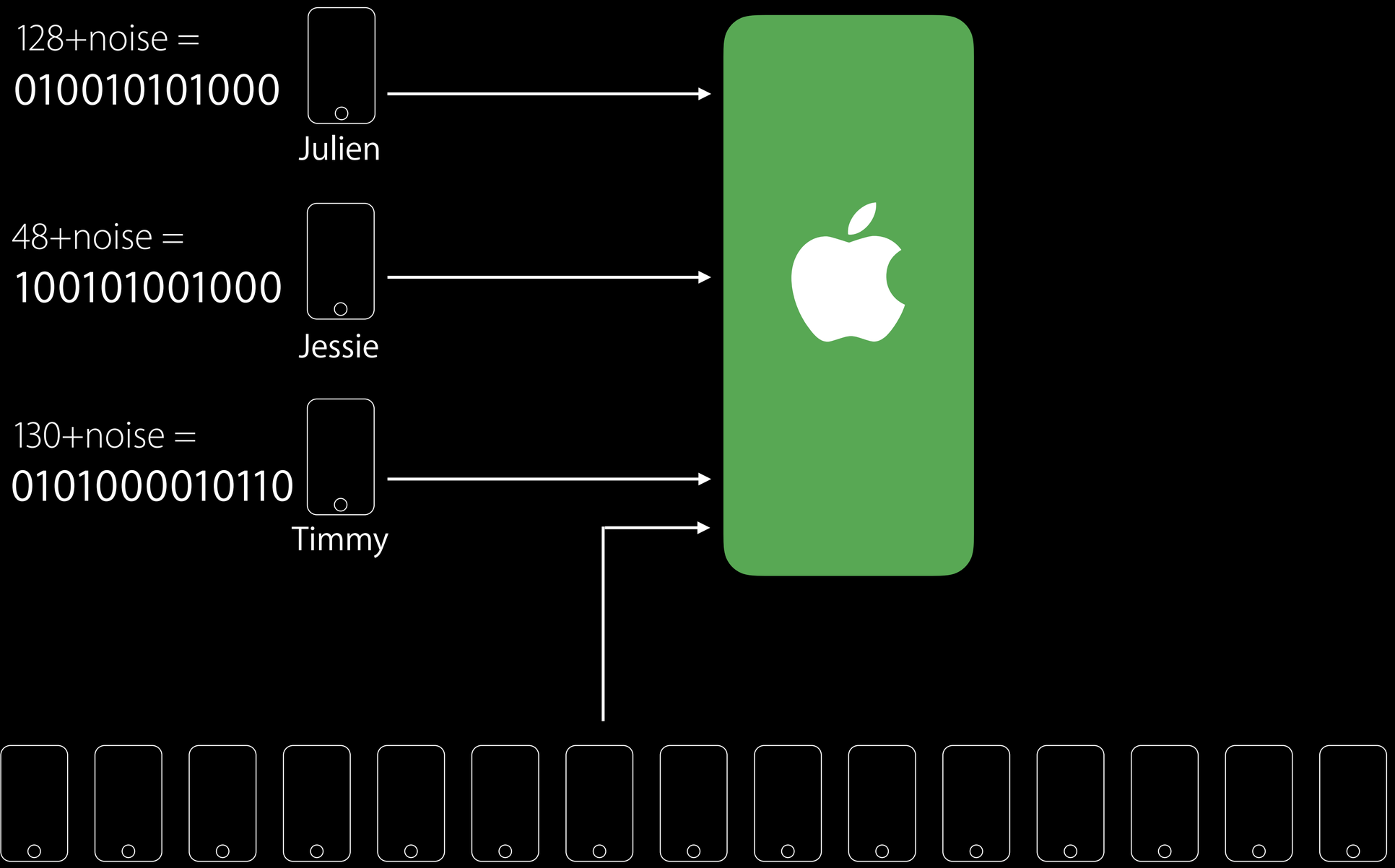
How Does Noise Work?

Original value	128
Compute projection	00000000010000000000
	00010101000000011000

Local


128+noise =
010010101000
Julien
48+noise =
100101001000
Jessie
130+noise =
0101000010110
Timmy

Local


128+noise =
010010101000
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100101001000
Jessie
130+noise =
0101000010110
Timmy

0011010100010010101 0000010100010010100

1111010100010010100 0011010100011110100

0101001001001001011 1 0000011100010011101 00

0000000001001000010 0 0000011100011110001 00

1111010100010010100 0000000100000000000100

1111000000010010101 1010010100010000101 01 0011010100010010101

1100001001001000010 0 0011010100010010101

0011010100010010101 1111011100000000010101

1000000100010010101 0011110100000010101 00

0011011100000000010101 0011010101110010001 00

Average = 41 hours

…00000000000000010000…

So What?

Learn popular items privately

Average

Presence of certain attributes

Frequencies

Differential Privacy Over Time

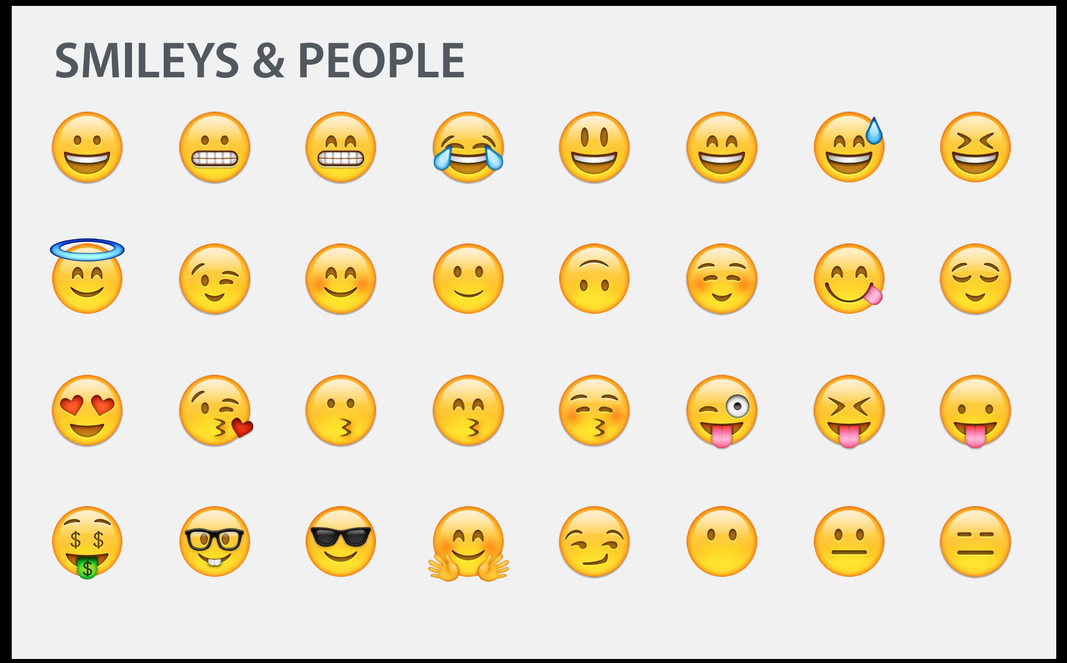
Privacy budget

Restrict the number of submissions made during a period

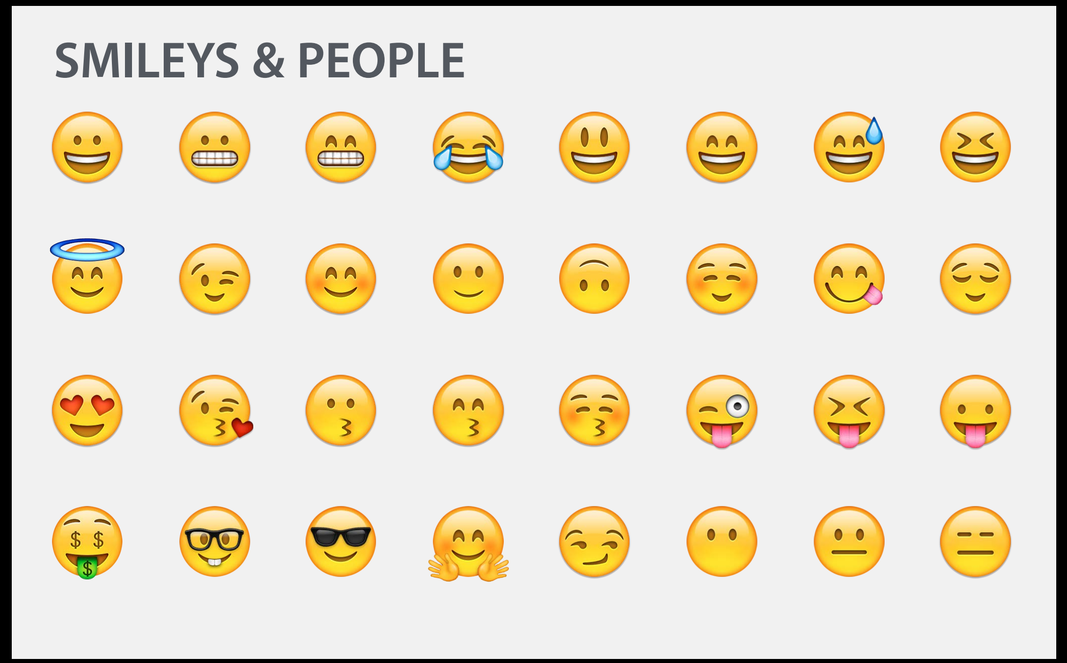
No identifiers

Periodically delete donations from server

Learning Popular Emojis with Privacy



Learning Popular Emojis with Privacy



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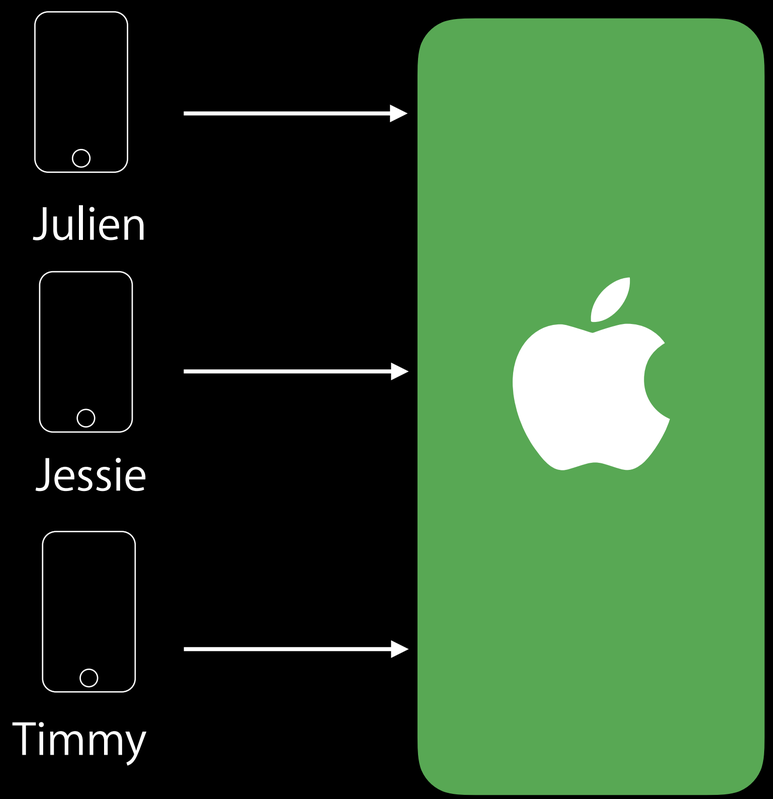
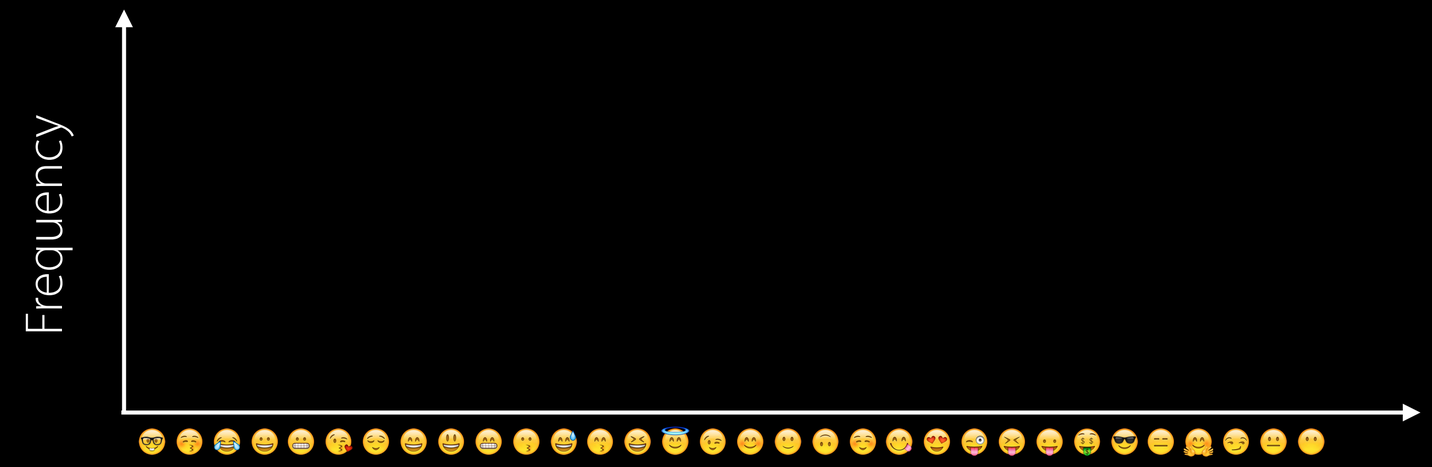
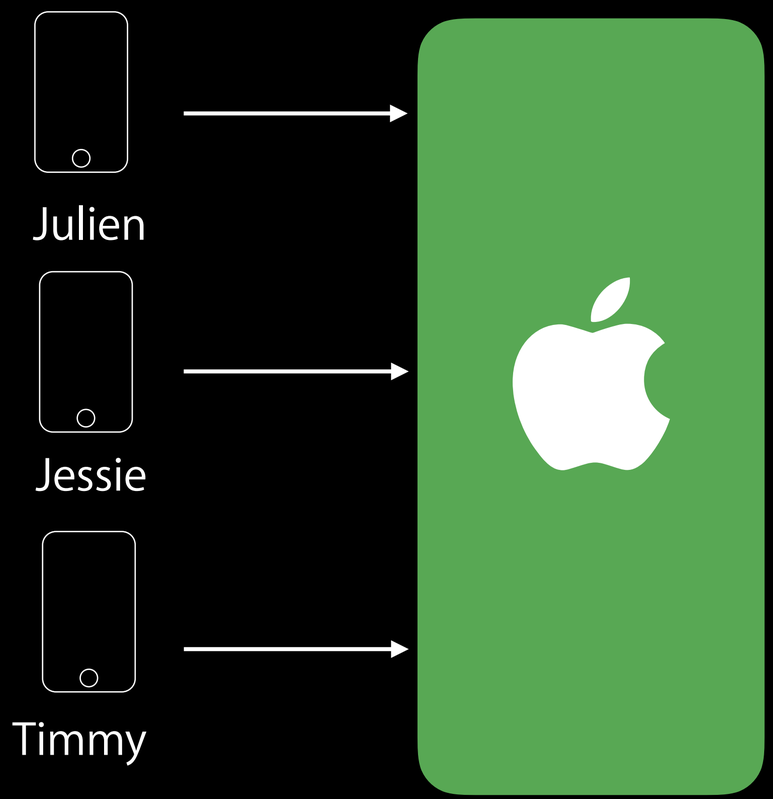
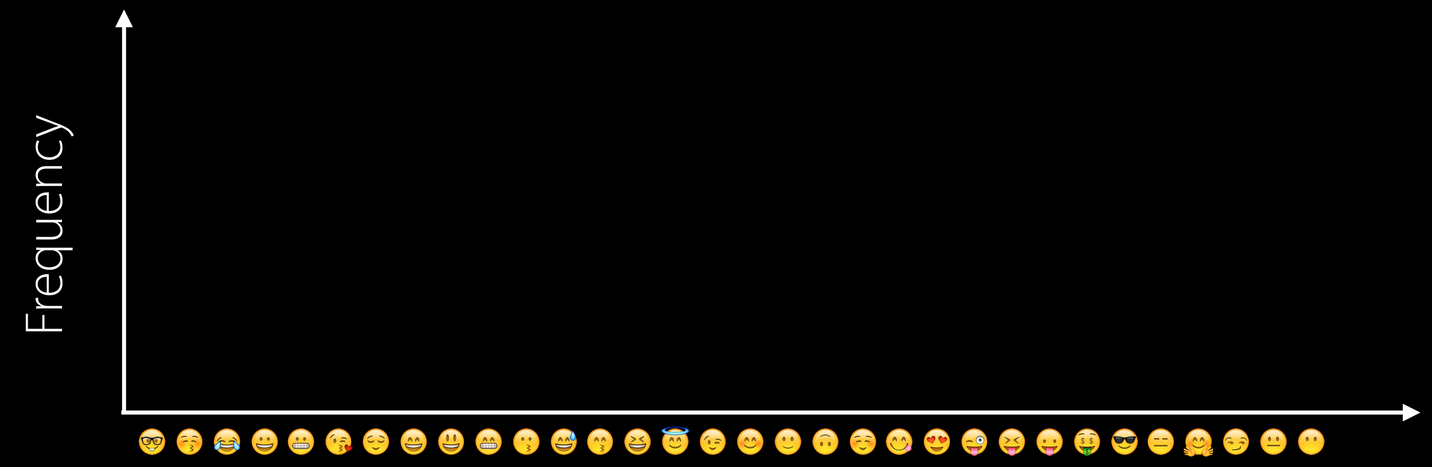


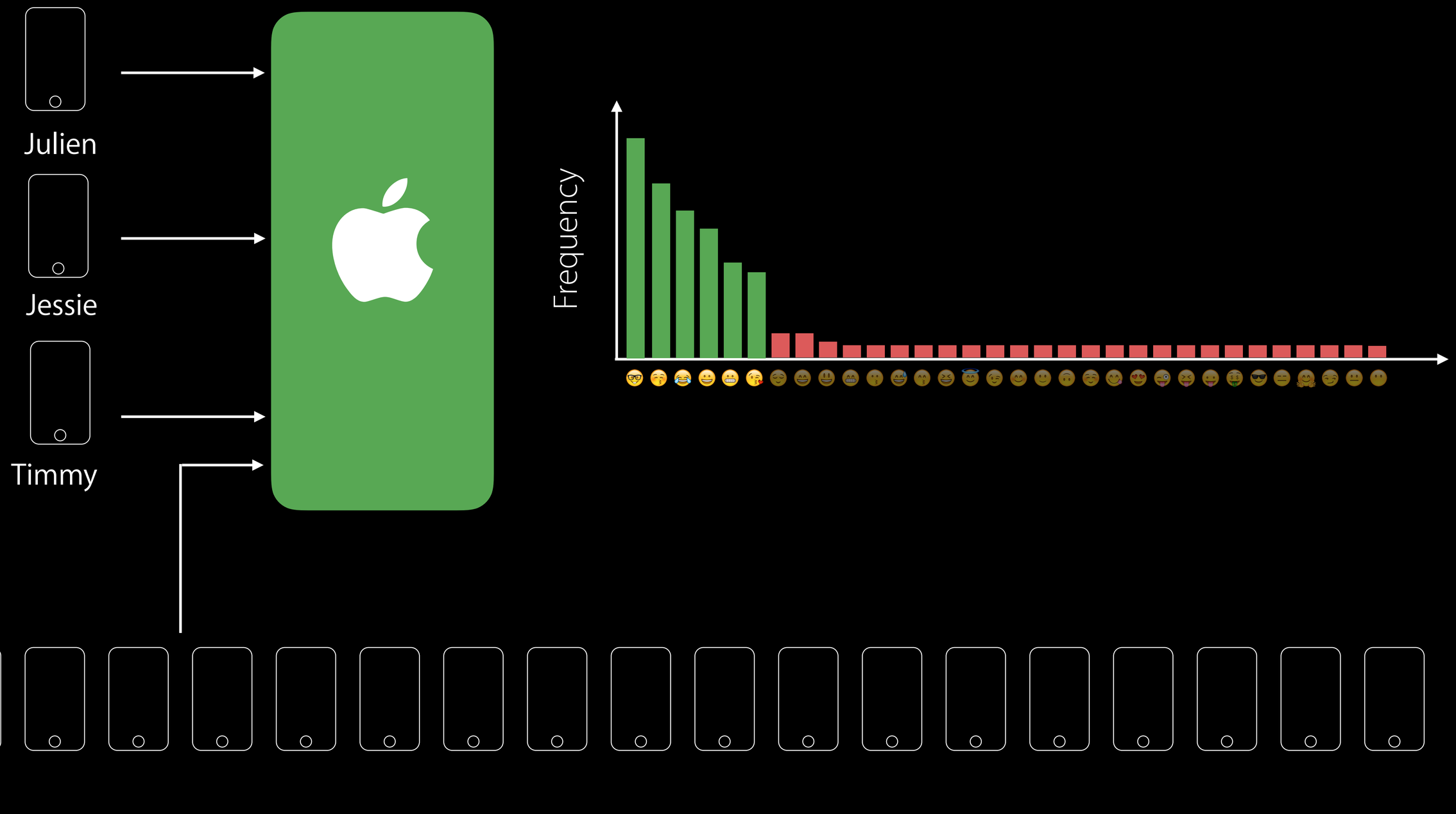


Learning Popular Emojis with Privacy

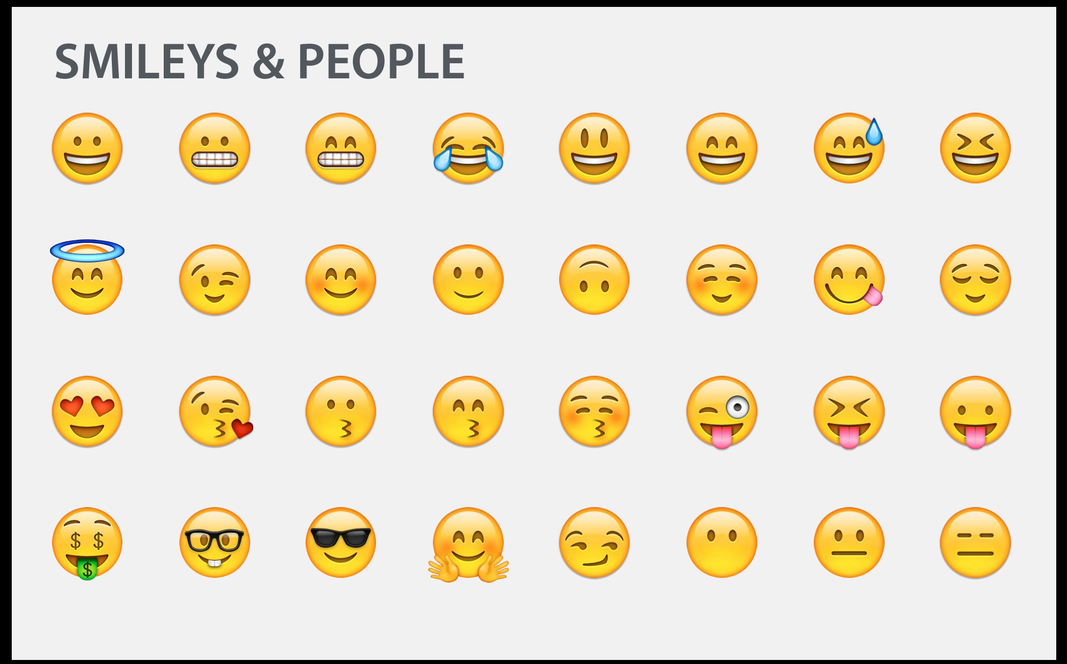




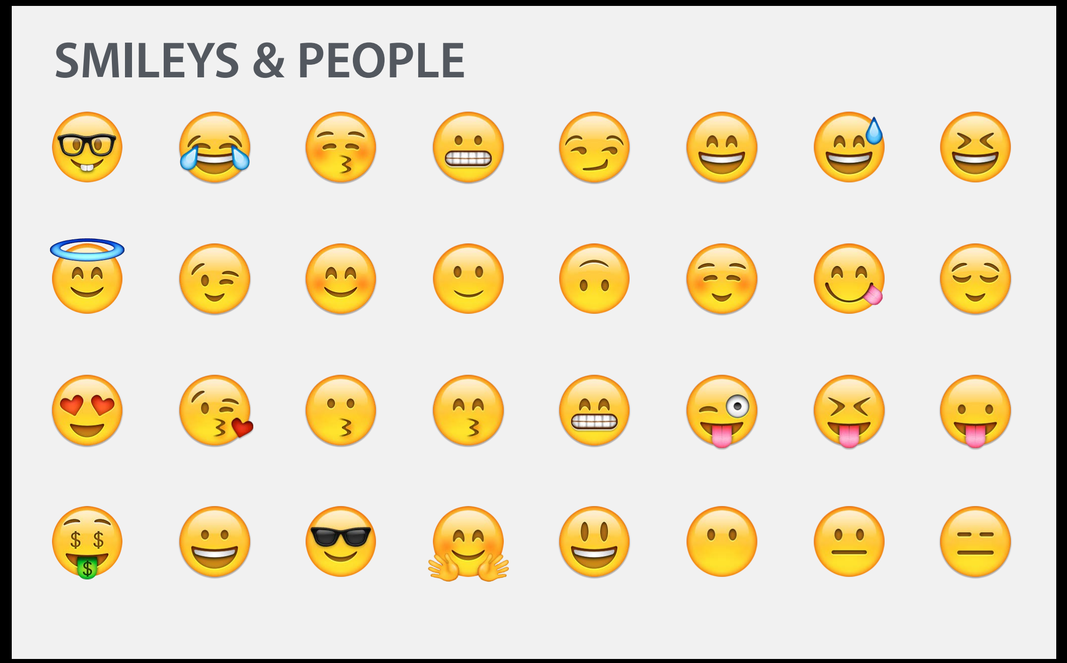
Learning Popular Emojis with Privacy



Crowd-Driven Insight with Privacy



Crowd-Driven Insight with Privacy



Use Cases

Use Cases

Emojis

Popular emojis

New words

Popular words unknown to QuickType dictionary

Deeplinks (iOS)

Popular deeplinks within apps marked as "eligible for public indexing”

Lookup Hints in Notes

Popularly highlighted hints

What Does this Mean for You?

Data collection via Differential Privacy

Crowd-driven insight at scale

Protects individuals

No identifiers

No raw measurements

Transparency and Control

9:41 AM 100%

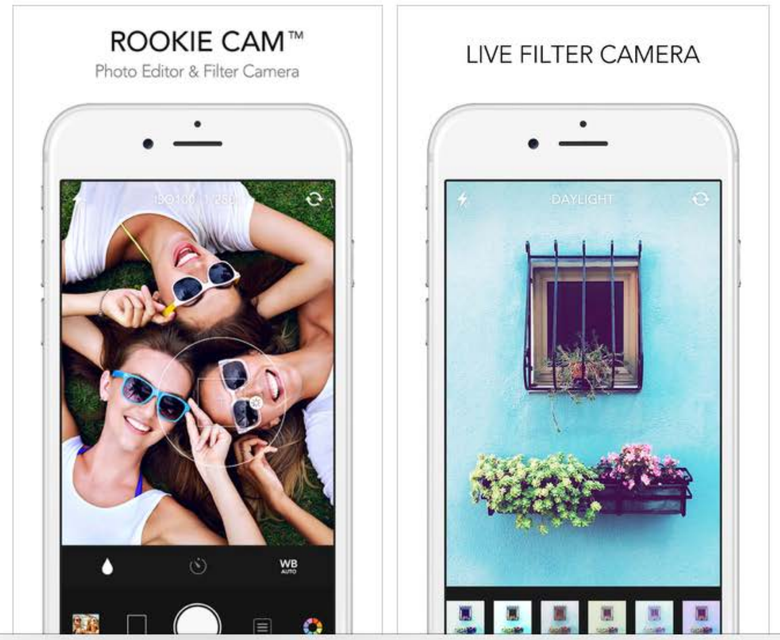
photo filters

Related: filters for pictures > photography effects > photo ed

LightRight
Ad OTOD Media
★★★★★ (646)
GET

LightRight gives photographers the capability to bookmark natural lighting conditions.

Rookie Cam - Photo Editor & Filter Camera
JellyBus Inc.
★★★★½ (6,420)
GET
In-App Purchases



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9:41 AM 100%

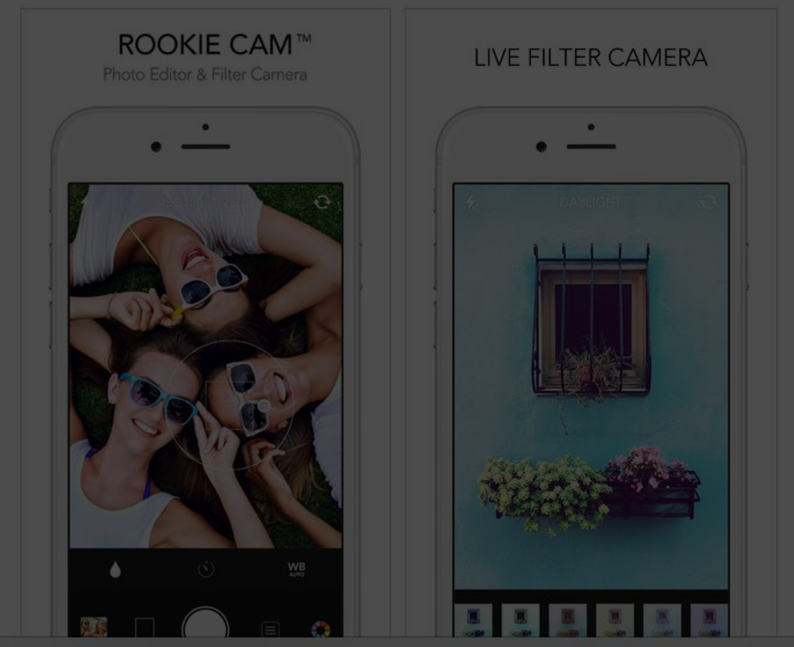
photo filters

Related: filters for pictures > photography effects > photo ed

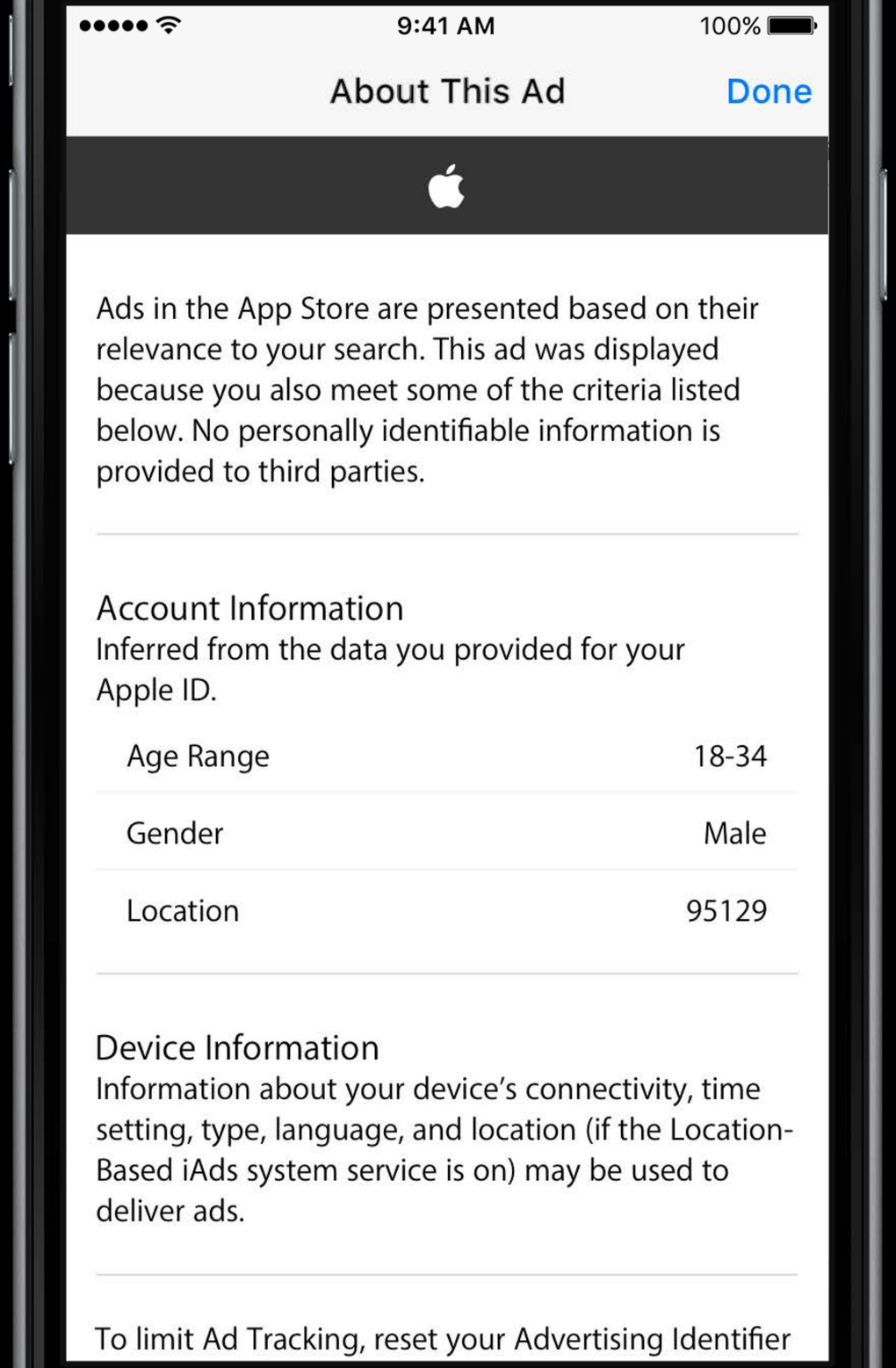
LightRight
Ad OD Media
★★★★ (646)
GET

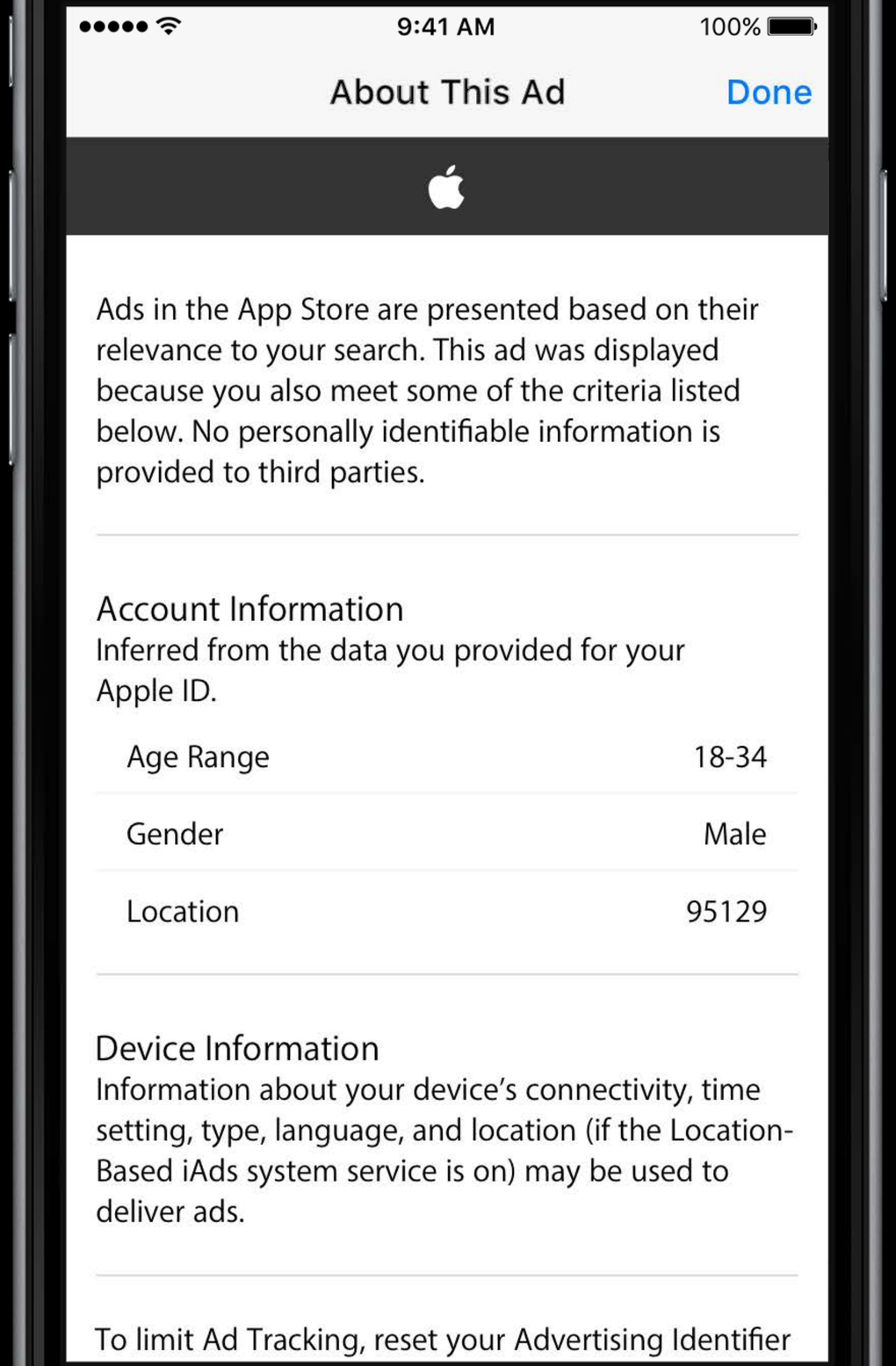
LightRight gives photographers the capability to bookmark natural lighting conditions.

Rookie Cam - Photo Editor & Filter Camera
JellyBus Inc.
★★★★½ (6,420)
GET
In-App Purchases



Featured Top Charts Explore Search Updates


9:41 AM
100%
About This Ad
Done
Ads in the App Store are presented based on their relevance to your search. This ad was displayed because you also meet some of the criteria listed below. No personally identifiable information is provided to third parties.
Account Information
Inferred from the data you provided for your Apple ID.
Age Range
18-34
Gender
Male
Location
95129
Device Information
Information about your device's connectivity, time setting, type, language, and location (if the Location-Based iAds system service is on) may be used to deliver ads.
To limit Ad Tracking, reset your Advertising Identifier


9:41 AM
100%
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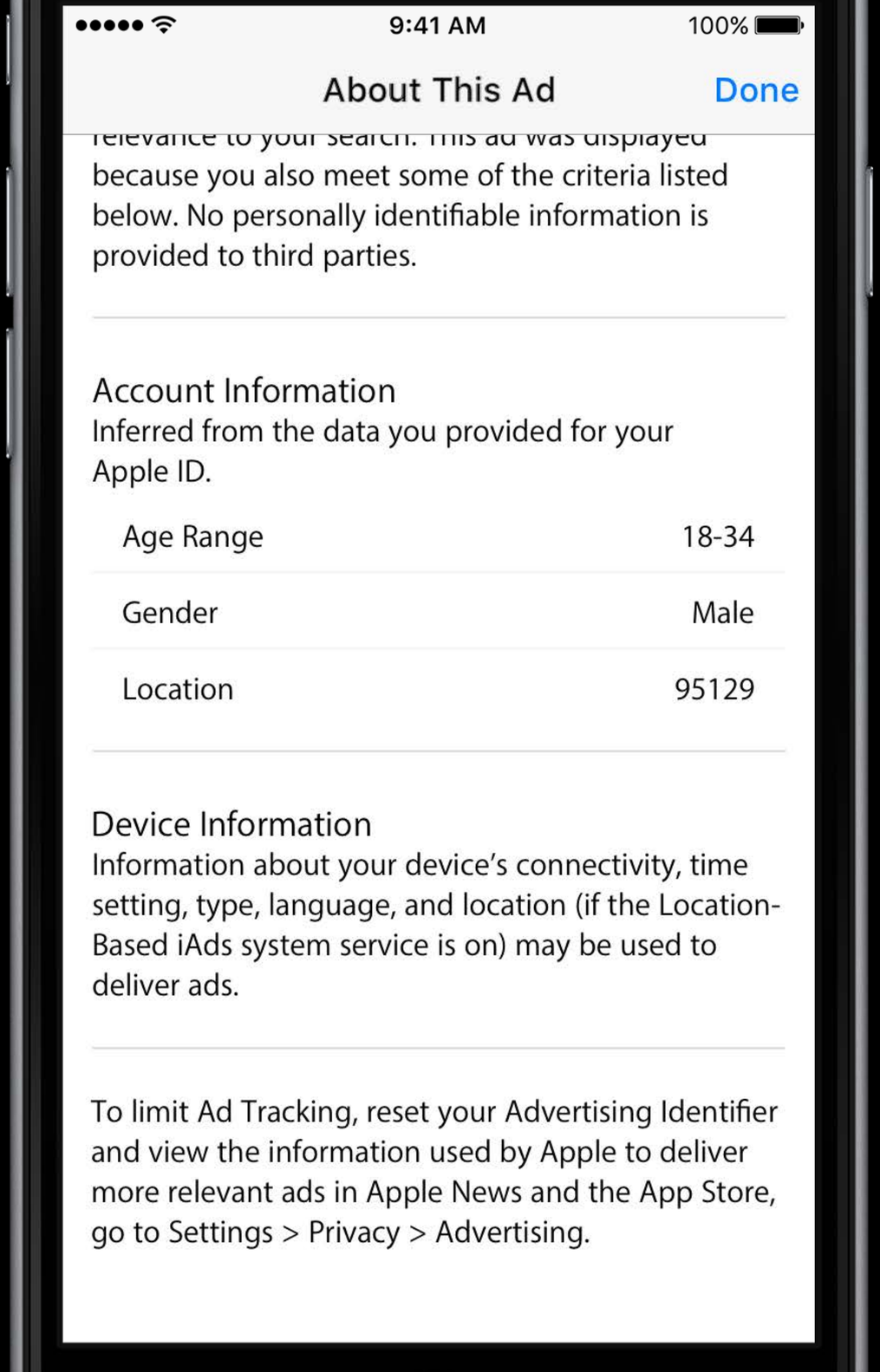
9:41 AM
100%
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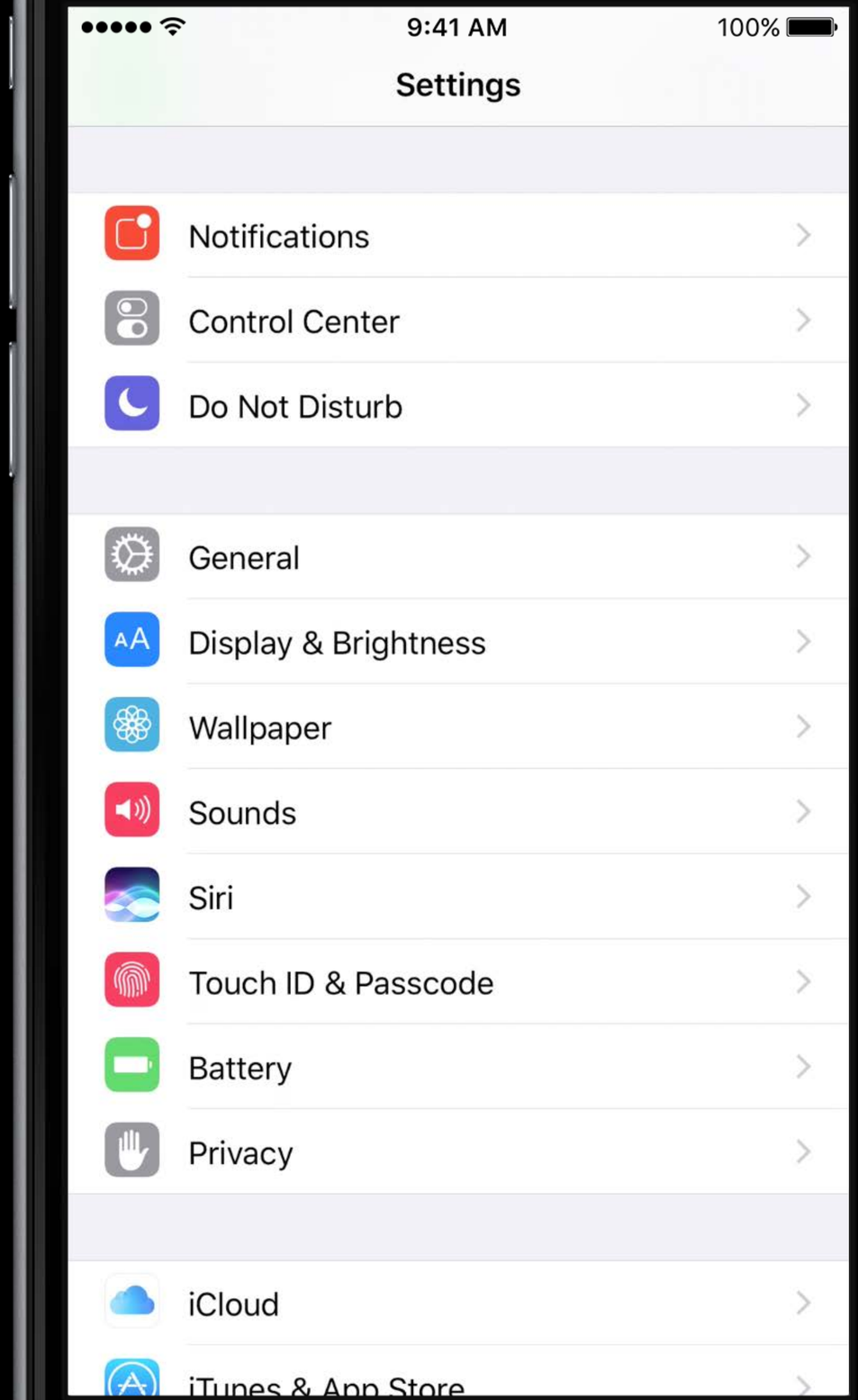
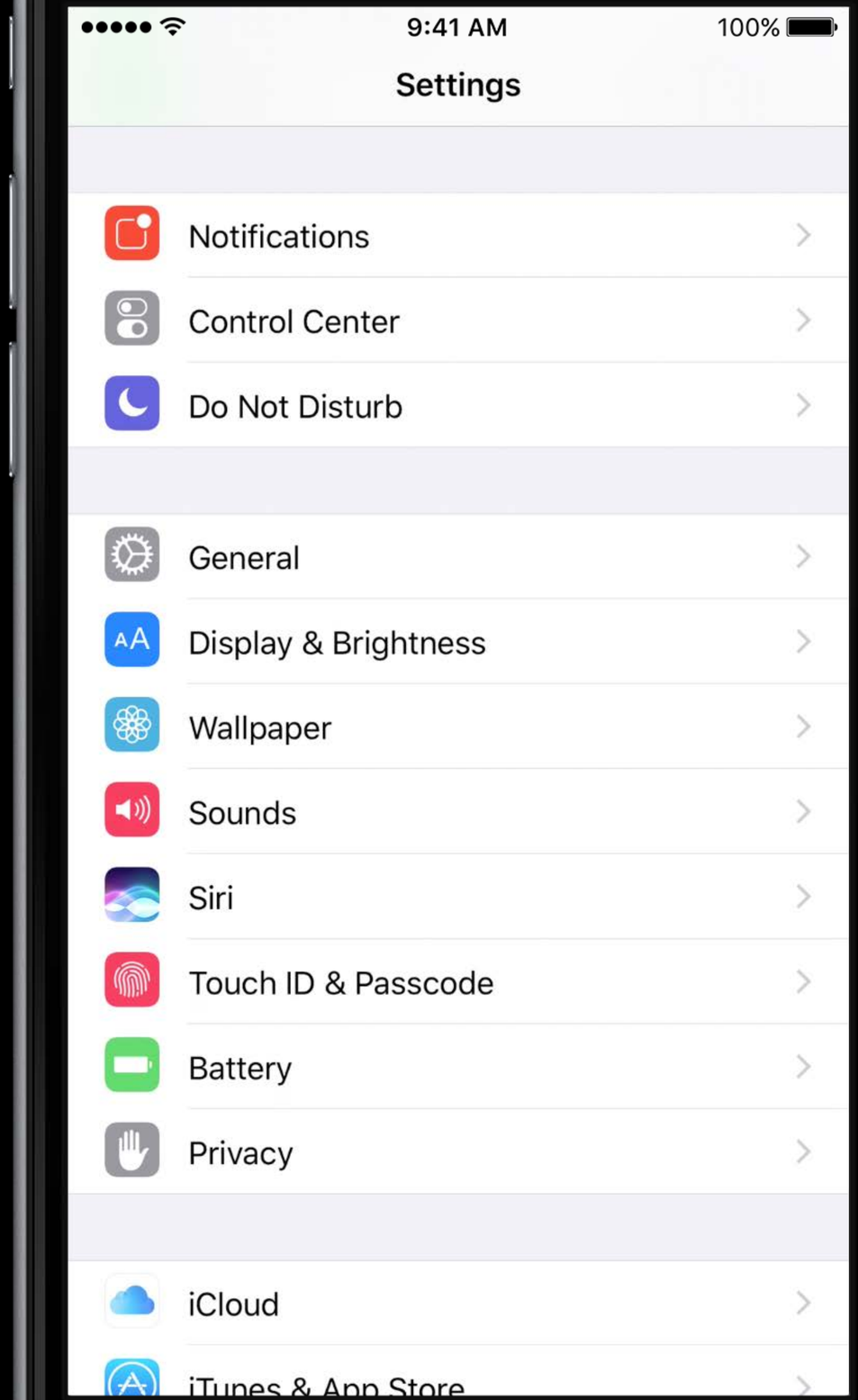
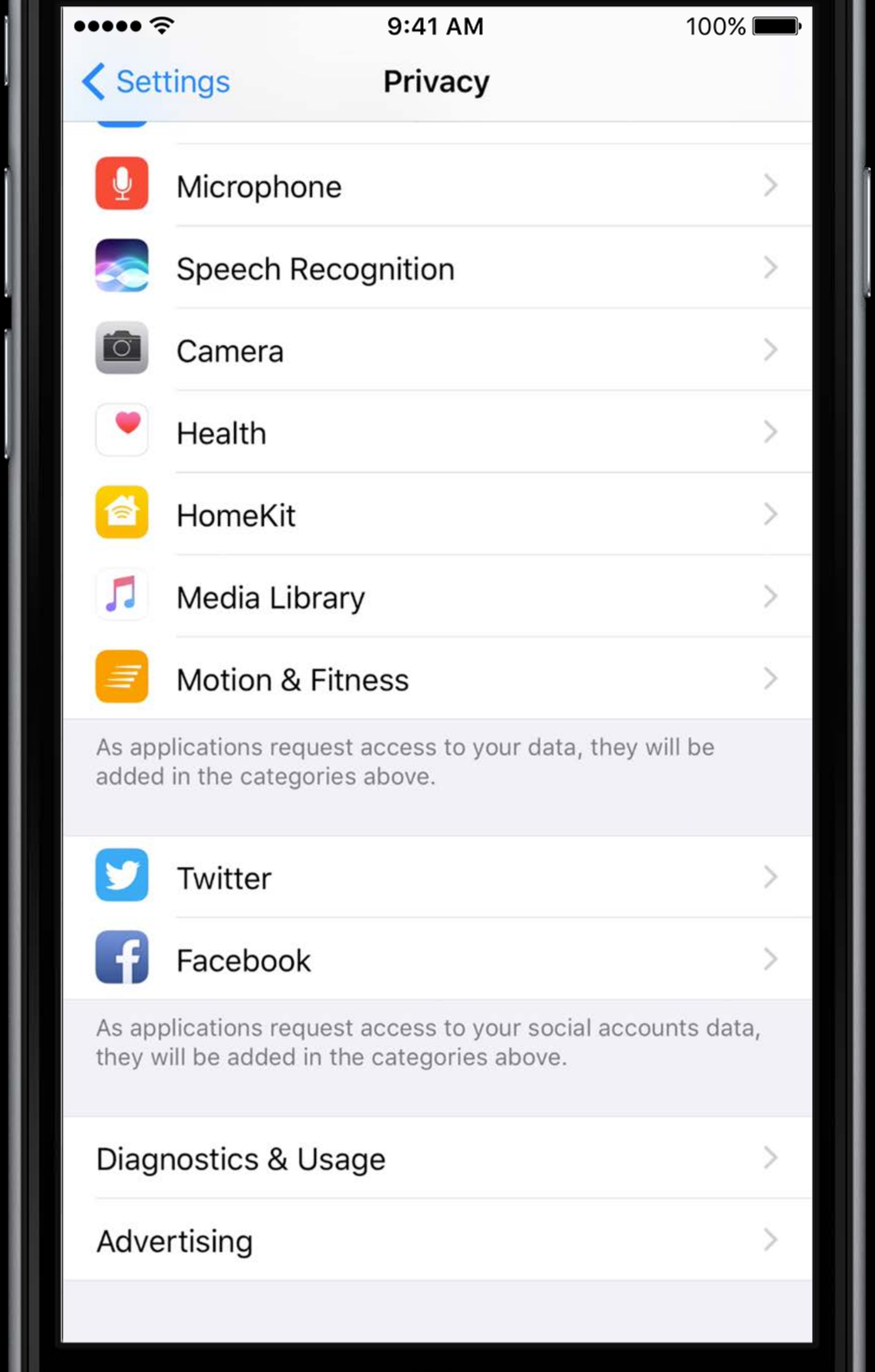
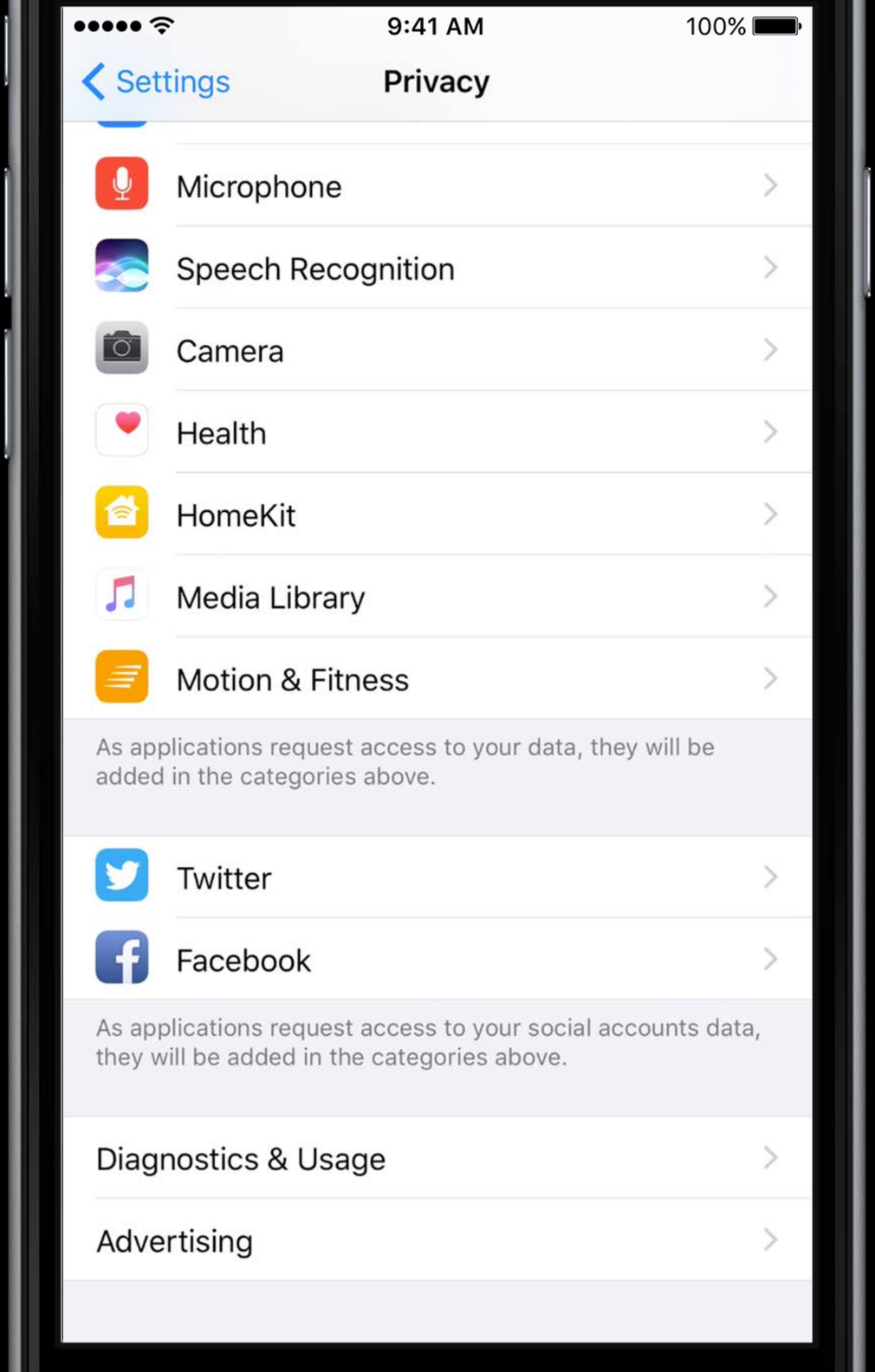
To limit Ad Tracking, reset your Advertising Identifier and view the information used by Apple to deliver more relevant ads in Apple News and the App Store, go to Settings > Privacy > Advertising.


9:41 AM
100%
Settings
Notifications
Control Center
Do Not Disturb
General
Display & Brightness
Wallpaper
Sounds
Siri
Touch ID & Passcode
Battery
Privacy
iCloud
iTunes & App Store


9:41 AM
100%
Settings
Notifications
Control Center
Do Not Disturb
General
Display & Brightness
Wallpaper
Sounds
Siri
Touch ID & Passcode
Battery
Privacy
iCloud
iTunes & App Store


9:41 AM
100%
Settings
Privacy
Microphone
Speech Recognition
Camera
Health
HomeKit
Media Library
Motion & Fitness
As applications request access to your data, they will be added in the categories above.
Twitter
Facebook
As applications request access to your social accounts data, they will be added in the categories above.
Diagnostics & Usage
Advertising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100%
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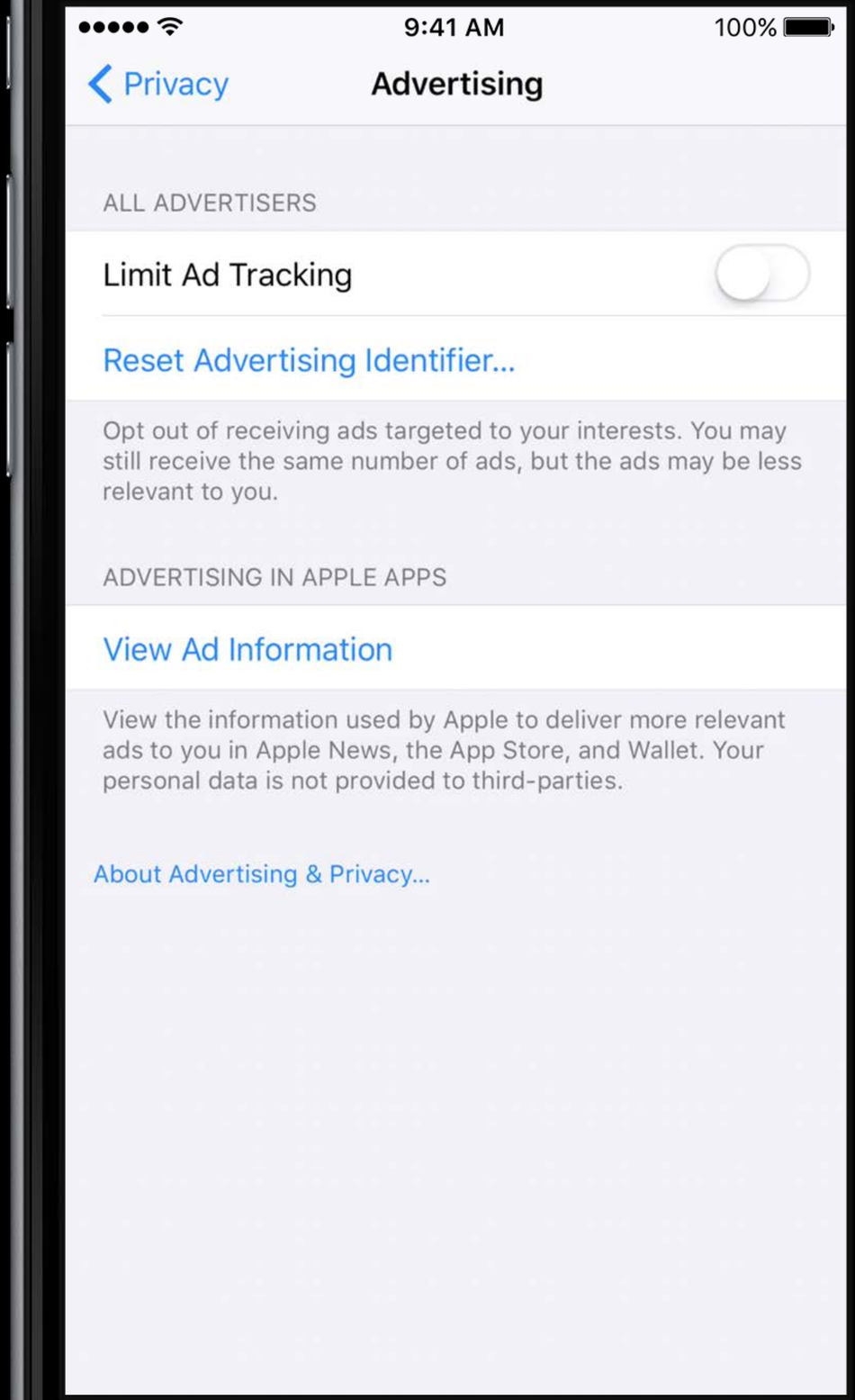
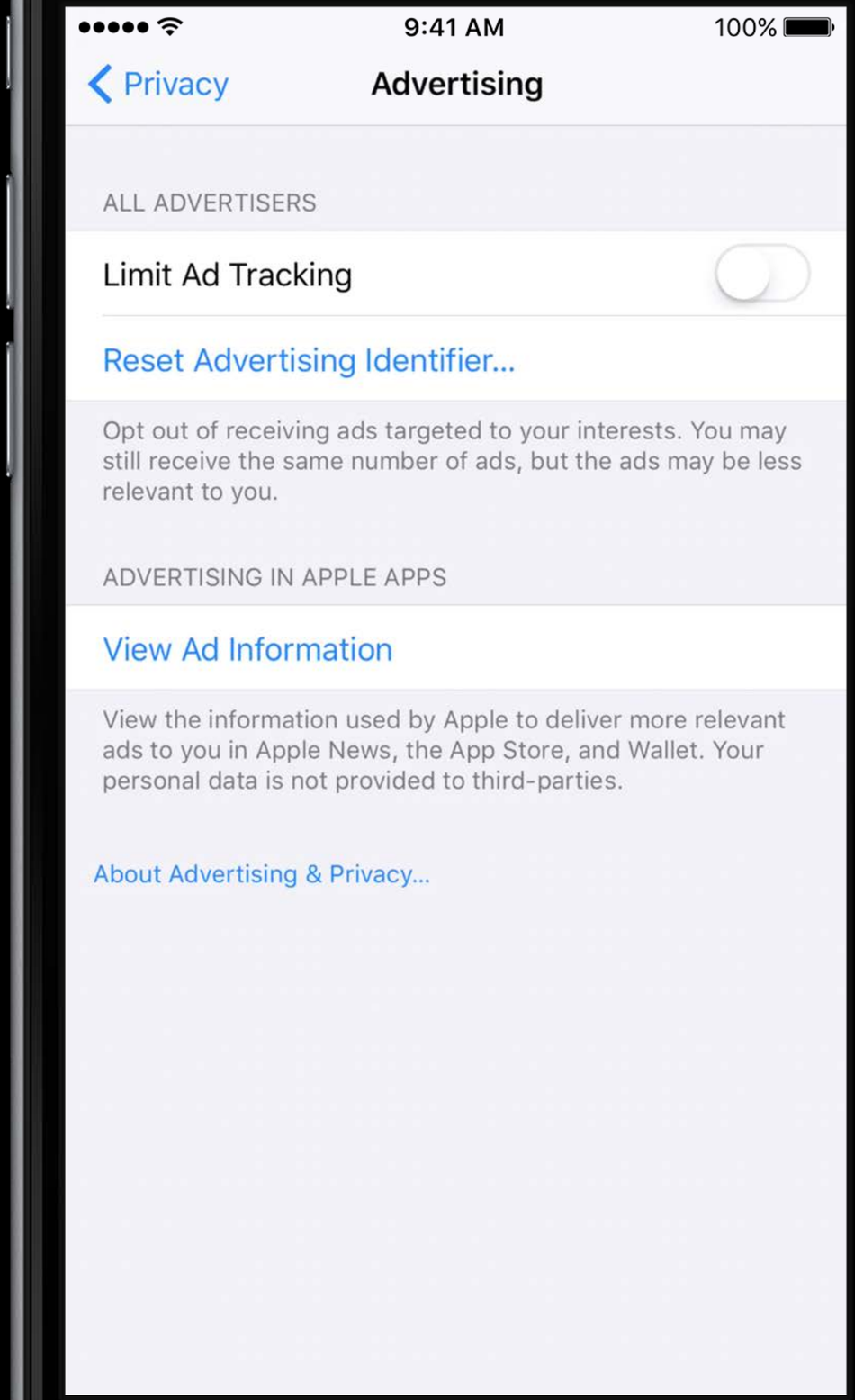

9:41 AM
100%
Privacy
Advertising
ALL ADVERTISERS
Limit Ad Tracking
Reset Advertising Identifier...
Opt out of receiving ads targeted to your interests. You may still receive the same number of ads, but the ads may be less relevant to you.
ADVERTISING IN APPLE APPS
View Ad Information
View the information used by Apple to deliver more relevant ads to you in Apple News, the App Store, and Wallet. Your personal data is not provided to third-parties.
About Advertising & Privacy...


9:41 AM
100%
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Advertising
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View Ad Information
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About Advertising & Privacy...

9:41 AM 100%

Ad Information Done

The following information is associated with an anonymous identifier and is used by Apple to deliver more relevant ads in Apple News, the App Store, and Wallet. Your personal data is not provided to third parties.

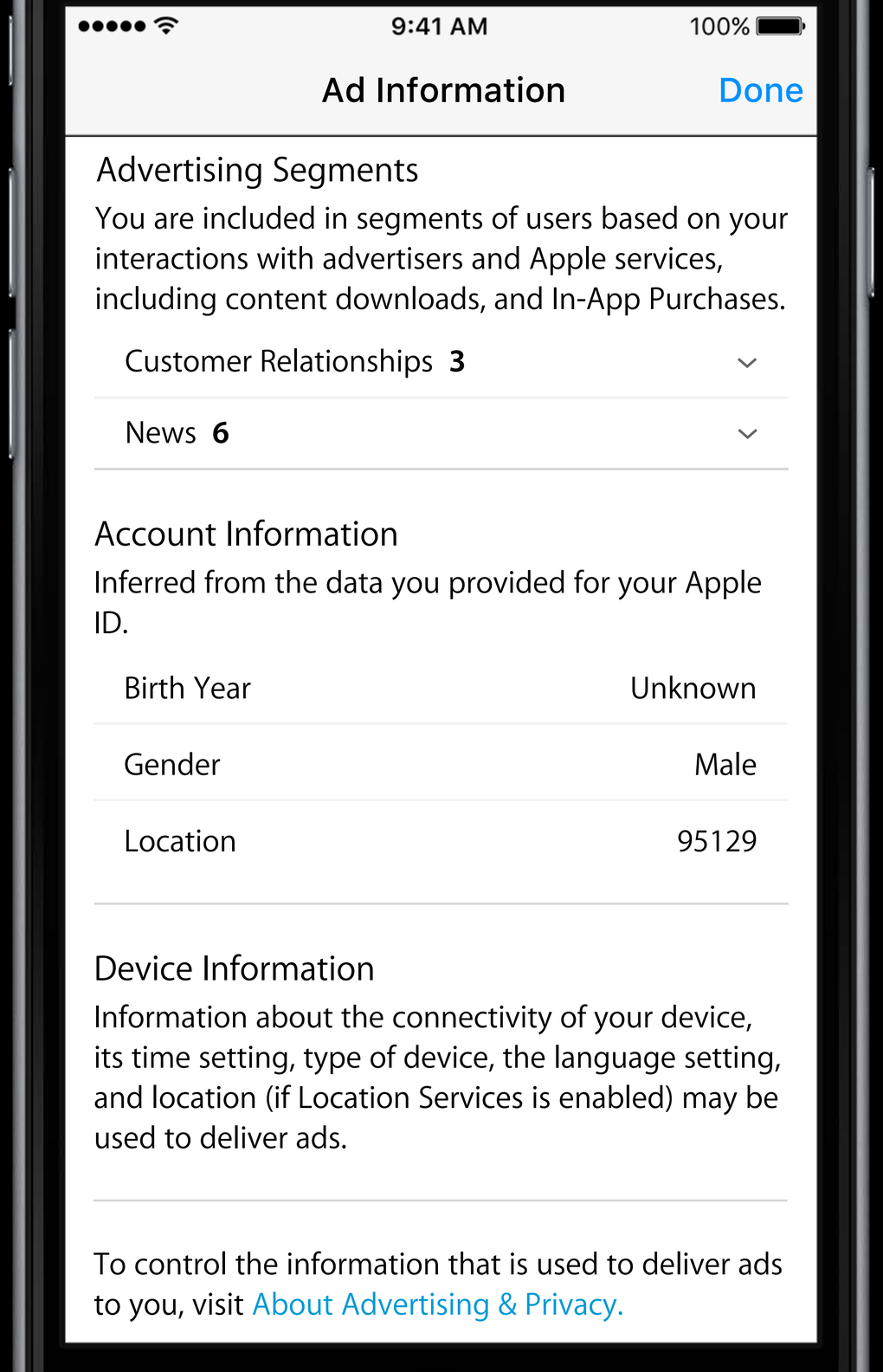
Content Categories

You have downloaded content from these iTunes Store and App Store categories.

- Apps **7**
- Audiobooks **3**
- Books **0**
- Movies **3**
- Music **3**
- TV **3**

Advertising Segments

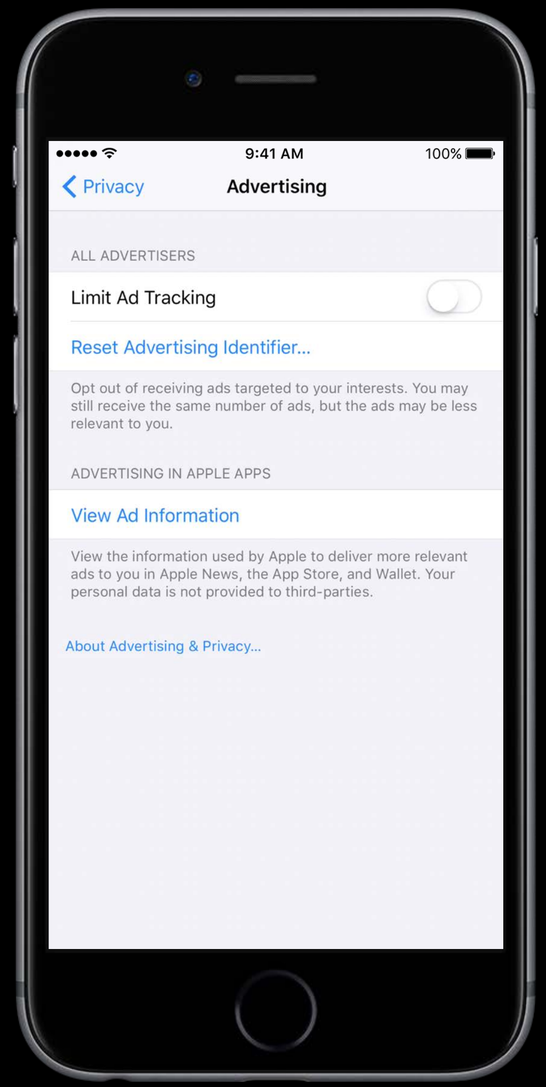
You are included in segments of users based on your interactions with advertisers and Apple services, including content downloads, and In-App Purchases.


9:41 AM
100%
Ad Information
Done
Advertising Segments
You are included in segments of users based on your interactions with advertisers and Apple services, including content downloads, and In-App Purchases.
Customer Relationships 3
News 6
Account Information
Inferred from the data you provided for your Apple ID.
Birth Year
Unknown
Gender
Male
Location
95129
Device Information
Information about the connectivity of your device, its time setting, type of device, the language setting, and location (if Location Services is enabled) may be used to deliver ads.
To control the information that is used to deliver ads to you, visit About Advertising & Privacy.

Limit Ad Tracking Disabled

Random Advertising ID

7d97c5e0-2424-11e6-abc5-0002a5d5c51b



Limit Ad Tracking Disabled

Random Advertising ID

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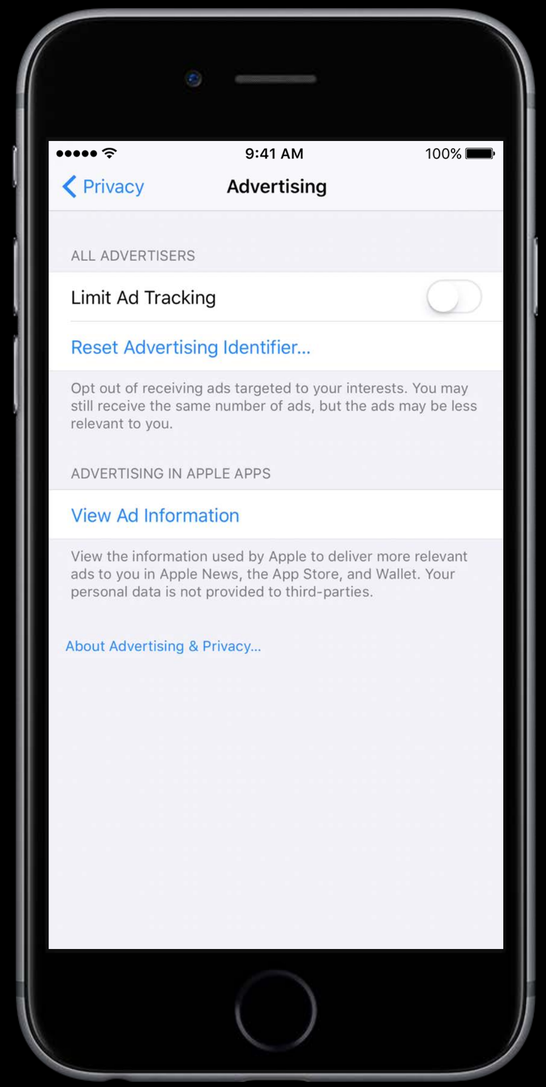

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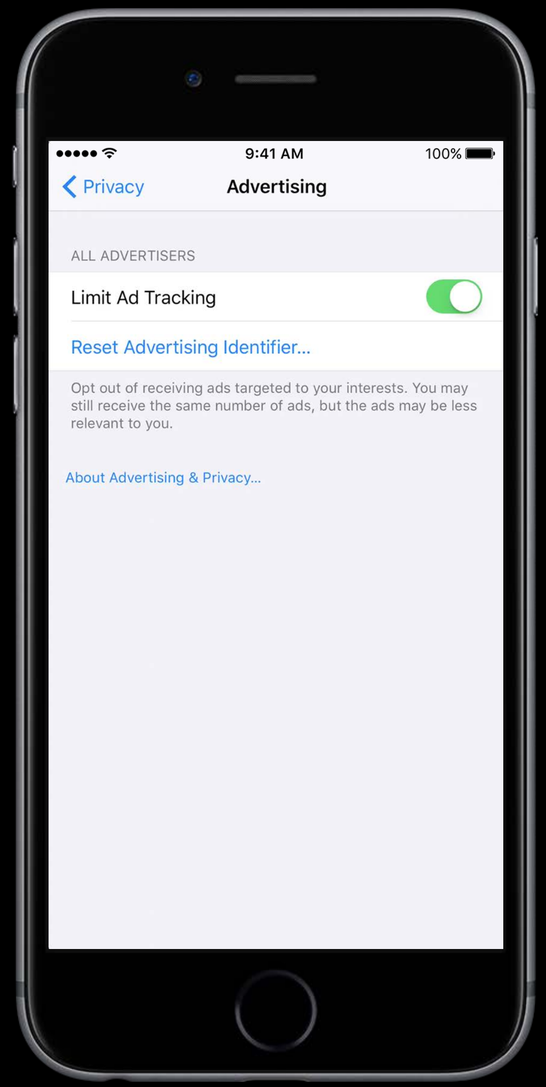

Limit Ad Tracking Disabled

Random Advertising ID

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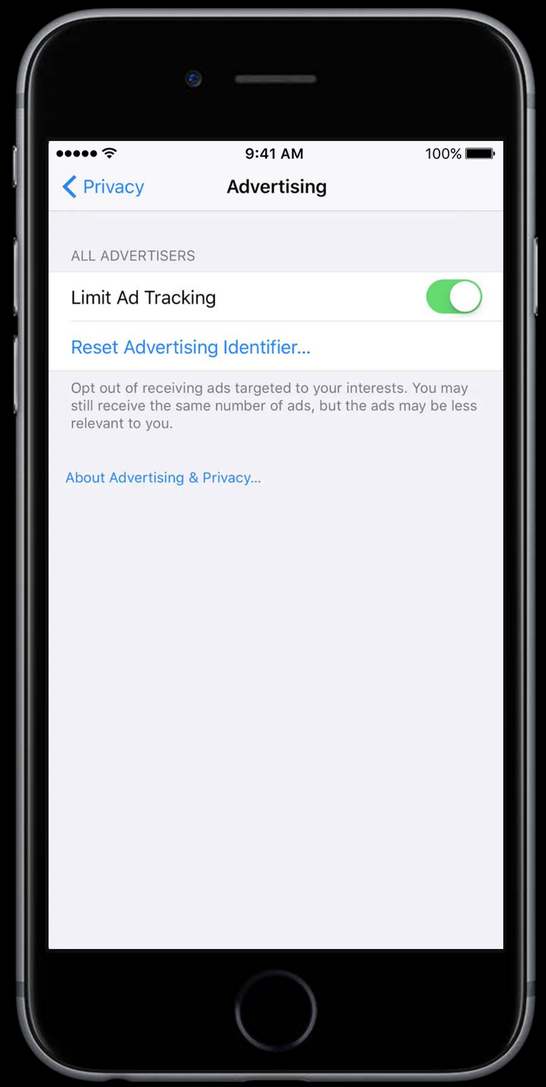

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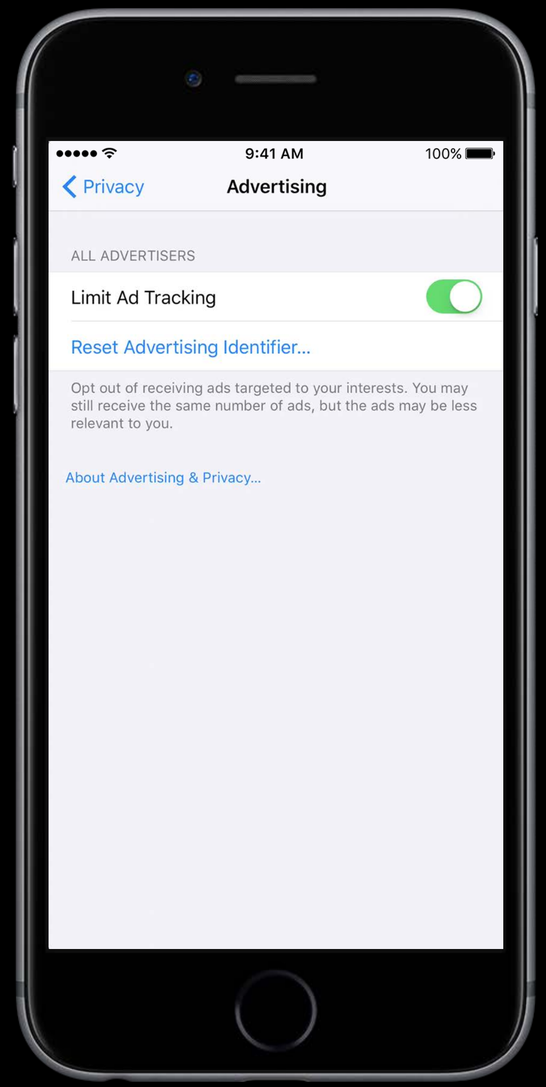
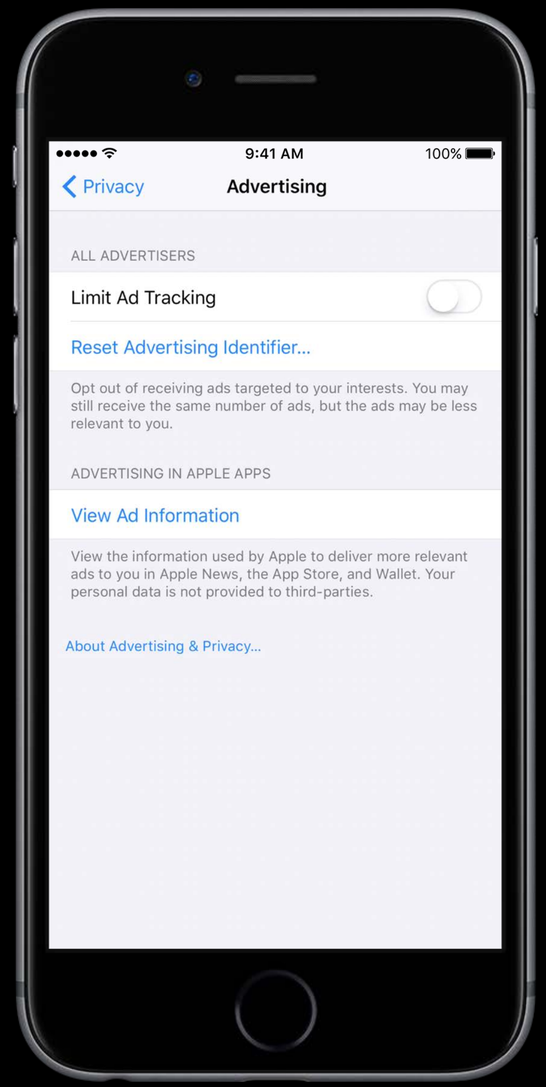


Limit Ad Tracking Disabled

Random Advertising ID

00000000-0000-0000-0000-000000000000



Limit Ad Tracking Disabled

Random Advertising ID

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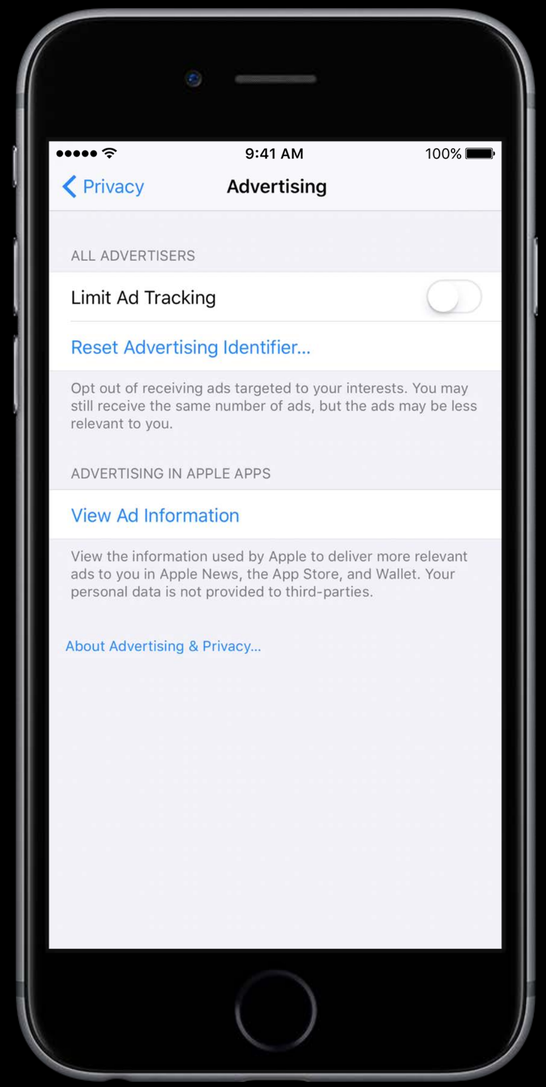


What Does That Mean For You?

What Does That Mean For You?

Increase in transparency for ads surfaced to users

What Does That Mean For You?

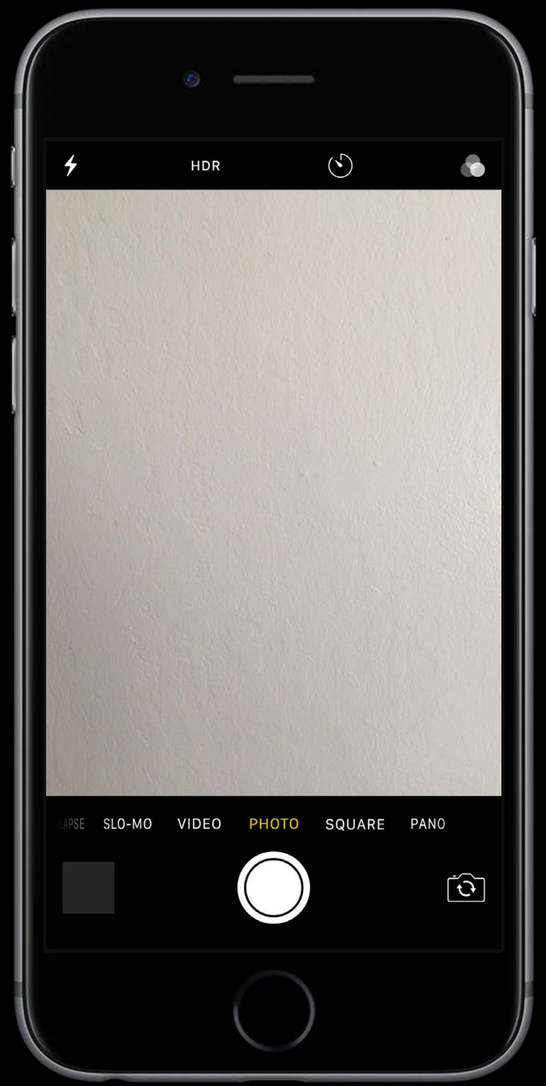
Increase in transparency for ads surfaced to users

Limit Ad Tracking now supported in code

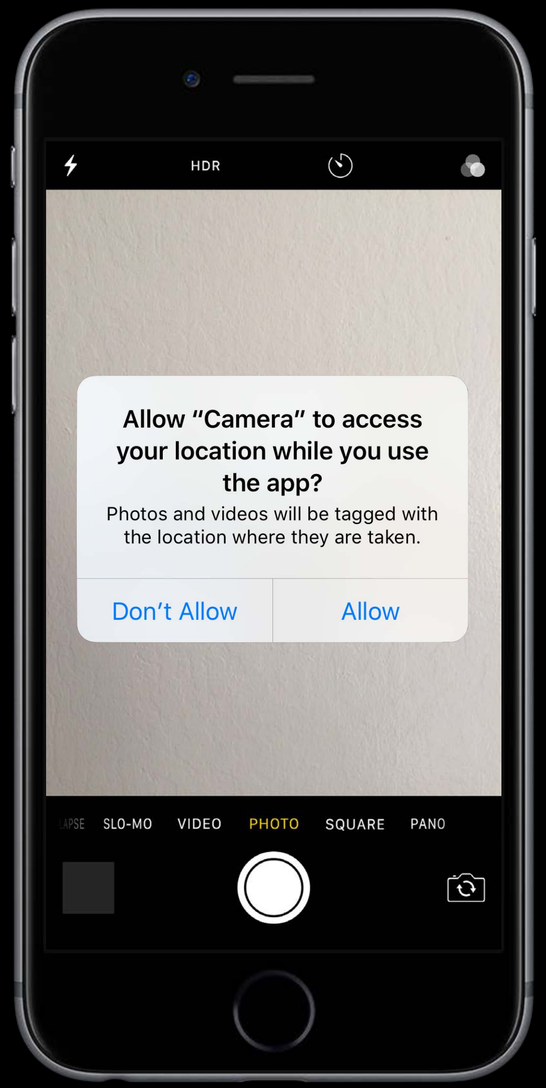
Meaningful Choices

Empowering users to make good privacy decisions

Consent Alerts



Consent Alerts



New Consent Alerts

Media Library Privacy Setting

iOS 10

NEW

Apple Music Subscriber status

Media Library Privacy Setting

iOS 10

NEW

Apple Music Subscriber status

```
SKCloudServiceController.requestCapabilities(completionHandler: (SKCloudServiceCapability,
NSError?) -> Void)
```

Media Library Privacy Setting

iOS 10

NEW

Apple Music Subscriber status

Apple Music Subscriber storefront

Media Library Privacy Setting

iOS 10

NEW

Apple Music Subscriber status

Apple Music Subscriber storefront

```
SKCloudServiceController.requestStorefrontIdentifier(completionHandler: (String?, NSError?)
-> Void)
```

Media Library Privacy Setting

NEW

iOS 10

Apple Music Subscriber status

Apple Music Subscriber storefront

Add content to a playlist

Media Library Privacy Setting

iOS 10

NEW

Apple Music Subscriber status

Apple Music Subscriber storefront

Add content to a playlist

```
MPMediaLibrary.defaultMediaLibrary().addItemWithProductID(productID: String,
completionHandler:(([MPMediaEntity], NSError?) -> Void)?)
```

Media Library Privacy Setting

NEW

iOS 10

Apple Music Subscriber status

Apple Music Subscriber storefront

Add content to a playlist

Read from media library

Media Library Privacy Setting

NEW

iOS 10

Apple Music Subscriber status

Apple Music Subscriber storefront

Add content to a playlist

Read from media library

```
MPMediaQuery.songs()
MPMediaQuery.playlists()
MPMediaQuery.audiobooks()
MPMediaQuery.podcasts()
```

Do I Already Have Access?

Do I Already Have Access?

```
SKCloudServiceController.authorizationStatus()

enum SKCloudServiceAuthorizationStatus : Int {
    case notDetermined
    case denied
    case restricted
    case authorized
}
```

Do I Already Have Access?

```
SKCloudServiceController.authorizationStatus()

enum SKCloudServiceAuthorizationStatus : Int {
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Do I Already Have Access?

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SKCloudServiceController.authorizationStatus()

enum SKCloudServiceAuthorizationStatus : Int {
    case notDetermined
    case denied
    case restricted
    case authorized
}
```

Speech Recognition

iOS 10

NEW

Speech Recognition

iOS 10

NEW

Speech transcription engine for use by apps

Speech Recognition

iOS 10

NEW

Speech transcription engine for use by apps

Speech transcription done on the user's behalf

Speech Recognition

iOS 10

NEW

Speech transcription engine for use by apps

Speech transcription done on the user's behalf

```
SFSpeechRecognizer.requestAuthorization(SFSpeechRecognizerAuthorizationStatus)
```

SiriKit

iOS 10

NEW

SiriKit

iOS 10

NEW

Users can make Siri requests that are completed with a third party app

SiriKit

iOS 10

NEW

Users can make Siri requests that are completed with a third party app

Apps must request access to receive requests via Siri

SiriKit

iOS 10

NEW

Users can make Siri requests that are completed with a third party app

Apps must request access to receive requests via Siri

```
INPreferences.requestSiriAuthorization()
```

TV Provider

iOS 10, tvOS 10

NEW

TV Provider

iOS 10, tvOS 10

NEW

Enabled television apps can request access to user subscription information

TV Provider

iOS 10, tvOS 10

NEW

Enabled television apps can request access to user subscription information

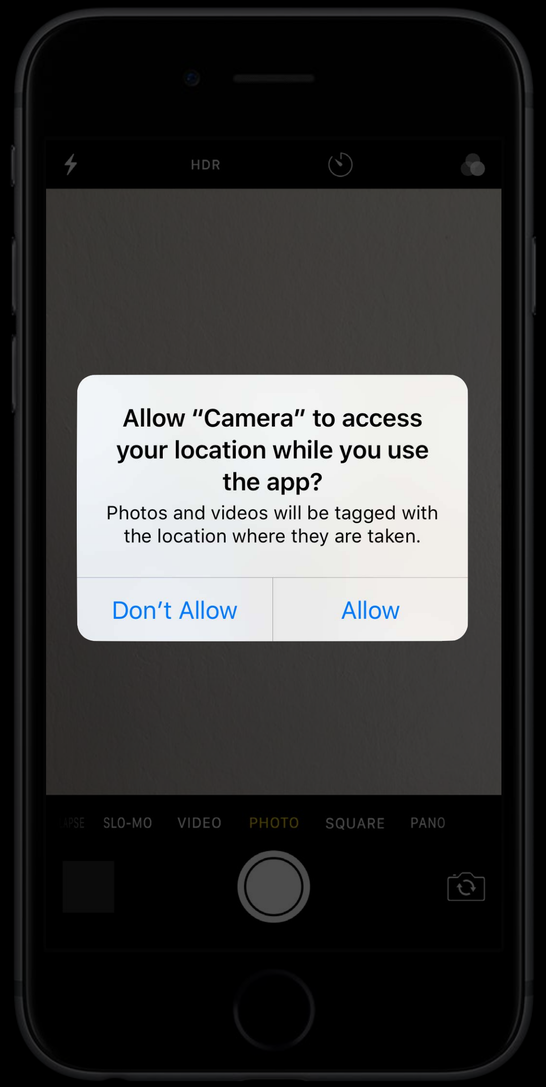
Reach out to your WWDR partner manager for more details

Photos on tvOS

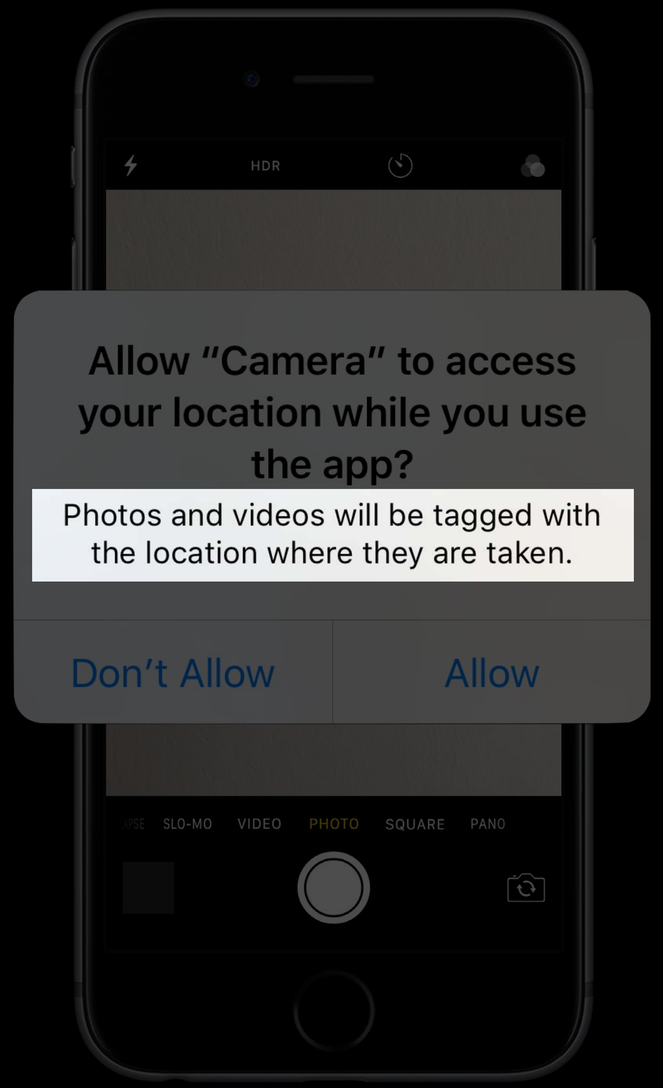
HomeKit on tvOS

Updates

Consent Alert Purpose String



Consent Alert Purpose String



Purpose String Required

iOS 10

Purpose String Required

iOS 10

Contacts

Calendar

Reminders

Photos

Bluetooth Sharing

Microphone

Camera

Location

Health—Sharing

Health—Updating

HomeKit

Media Library

Motion and Fitness

CallKit

Speech Recognition

SiriKit

TV Provider

Purpose String Required

tvOS 10

Photos

Location

HomeKit

TV Provider

Purpose String Key Names

Purpose String Key Names

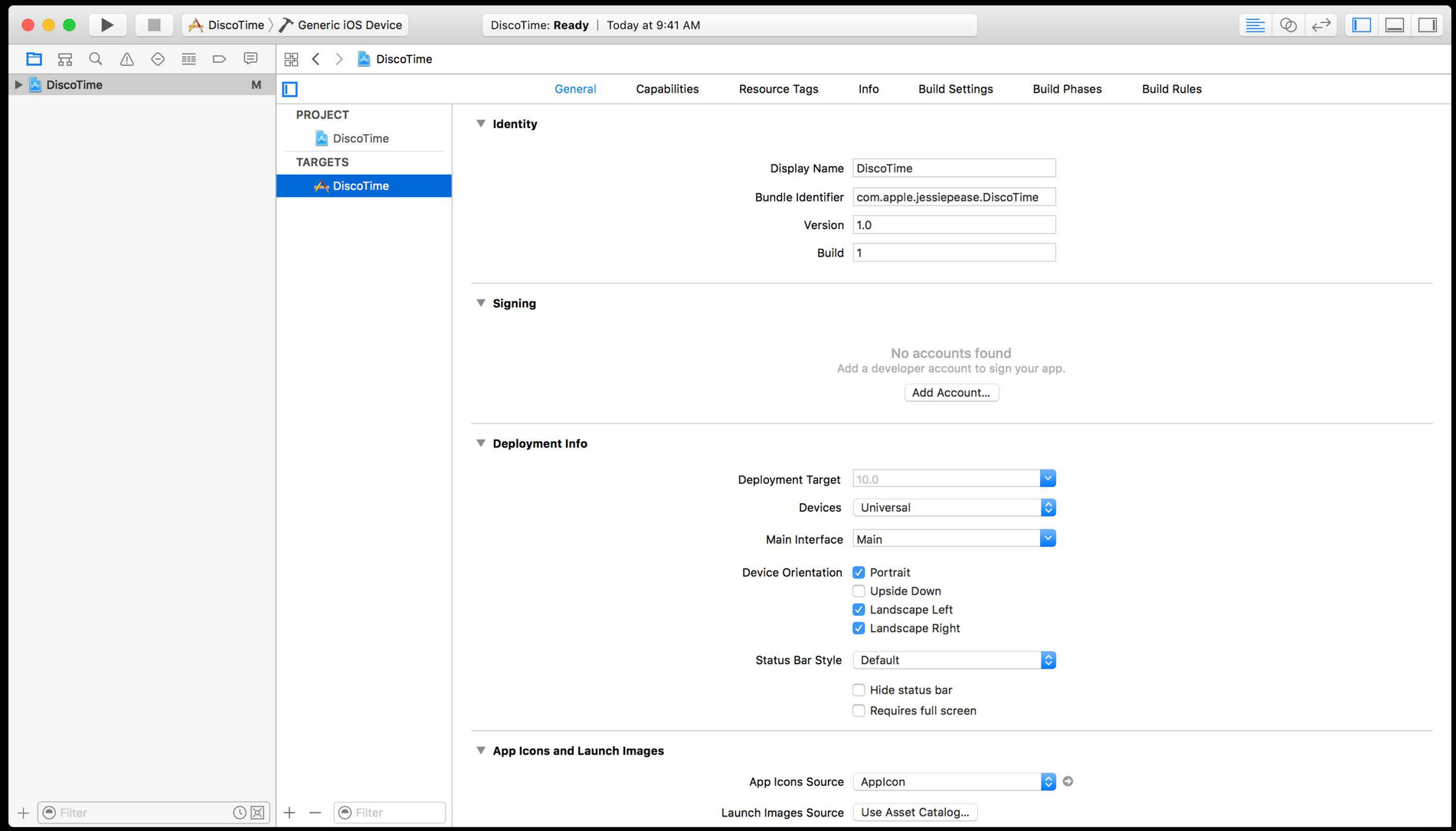
Contacts	NSContactsUsageDescription
Calendars	NSCalendarsUsageDescription
Reminders	NSRemindersUsageDescription
Photos	NSPhotoLibraryUsageDescription
Bluetooth Sharing	NSBluetoothPeripheralUsageDescription
Microphone	NSMicrophoneUsageDescription
Camera	NSCameraUsageDescription
Health—Sharing	NSHealthShareUsageDescription
Health—Updating	HSHealthUpdateUsageDescription

Purpose String Key Names

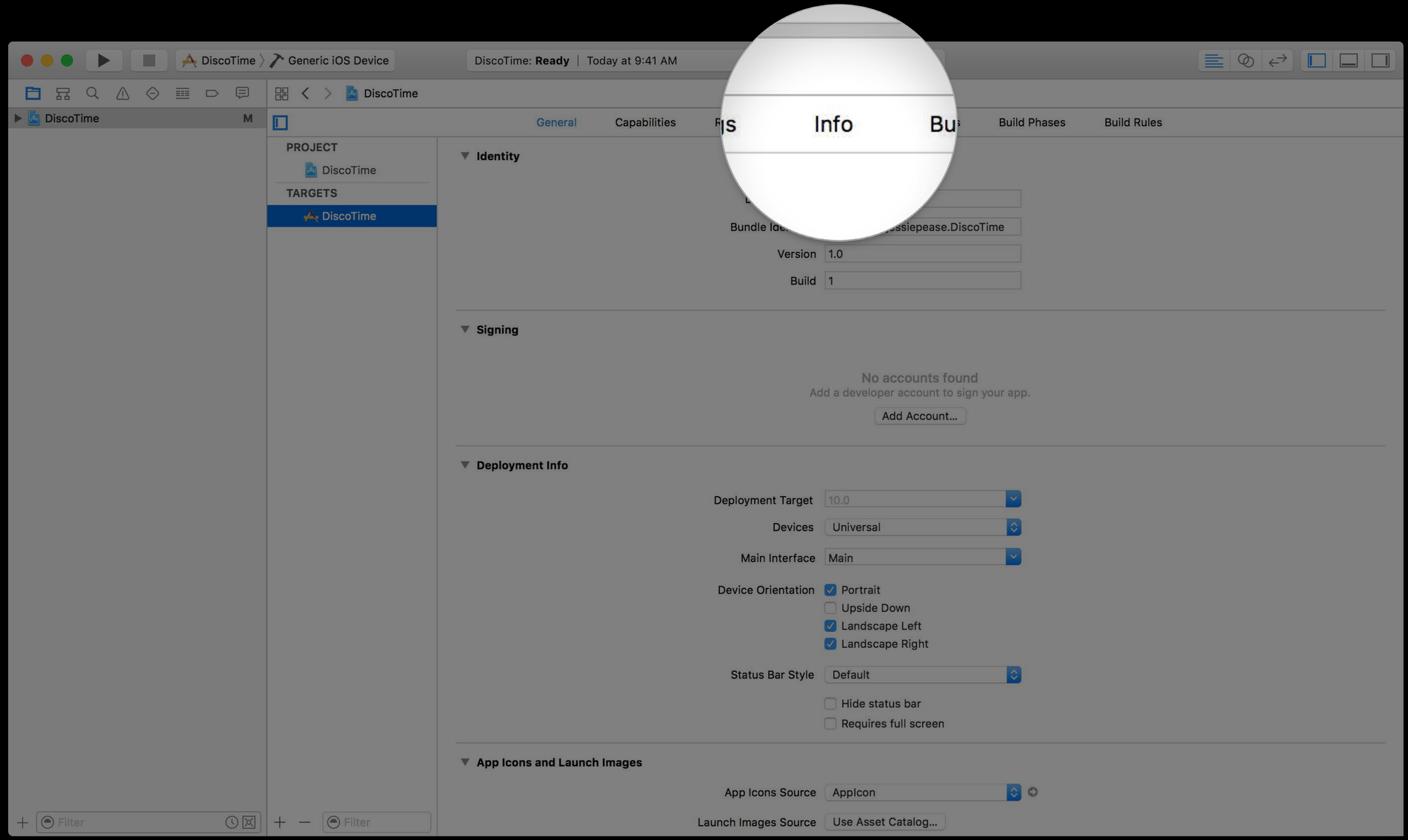
Purpose String Key Names

HomeKit	NSHomeKitUsageDescription
Media Library	NSAppleMusicUsageDescription
Motion and Fitness	NSMotionUsageDescription
CallKit	NSCallKitUsageDescription
Speech Recognition	NSSpeechRecognitionUsageDescription
Siri Third Party	NSSiriUsageDescription
TV Provider	NSVideoSubscriberAccountUsageDescription

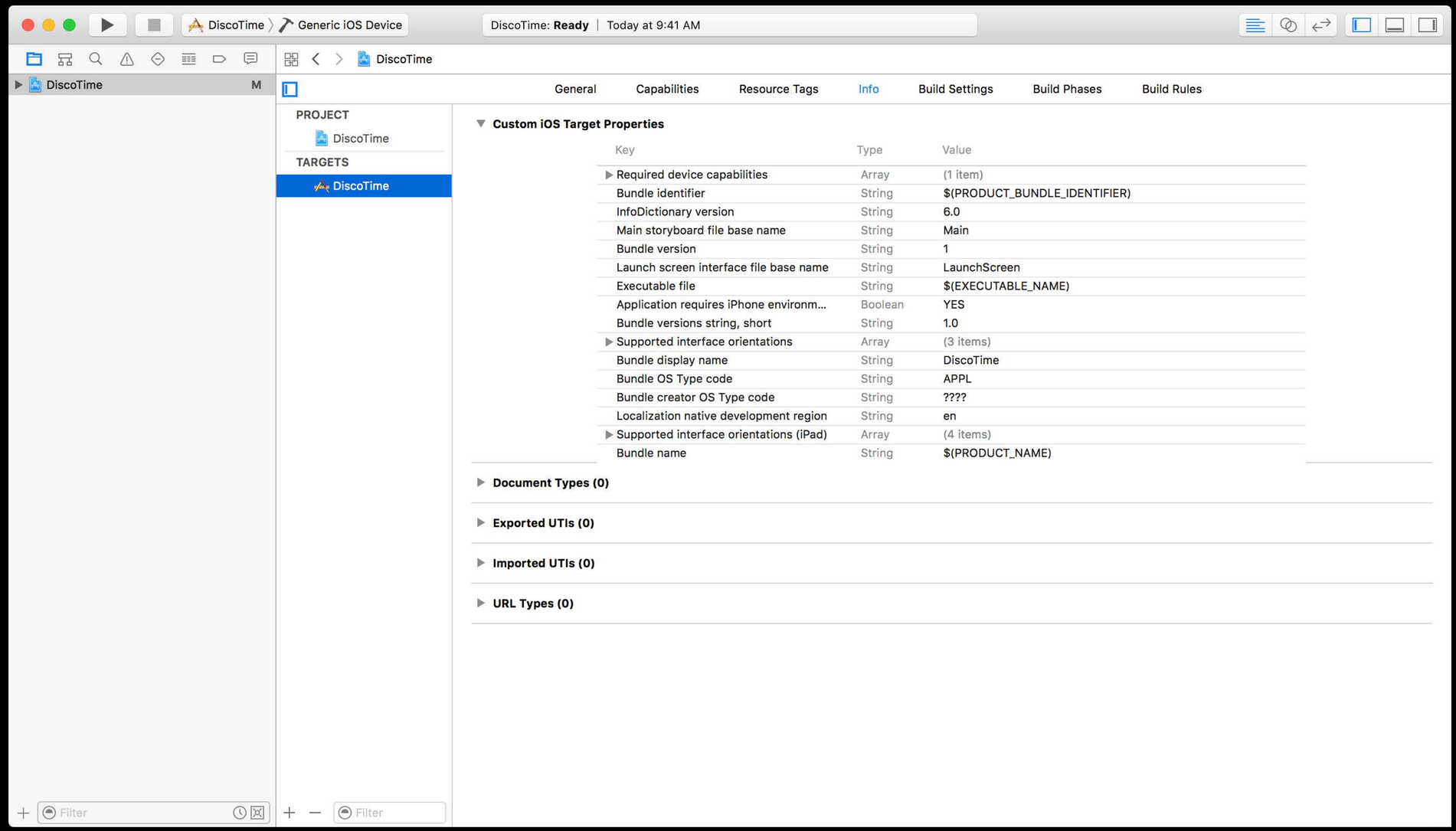
Add Purpose String in Xcode



Add Purpose String in Xcode



Add Purpose String in Xcode



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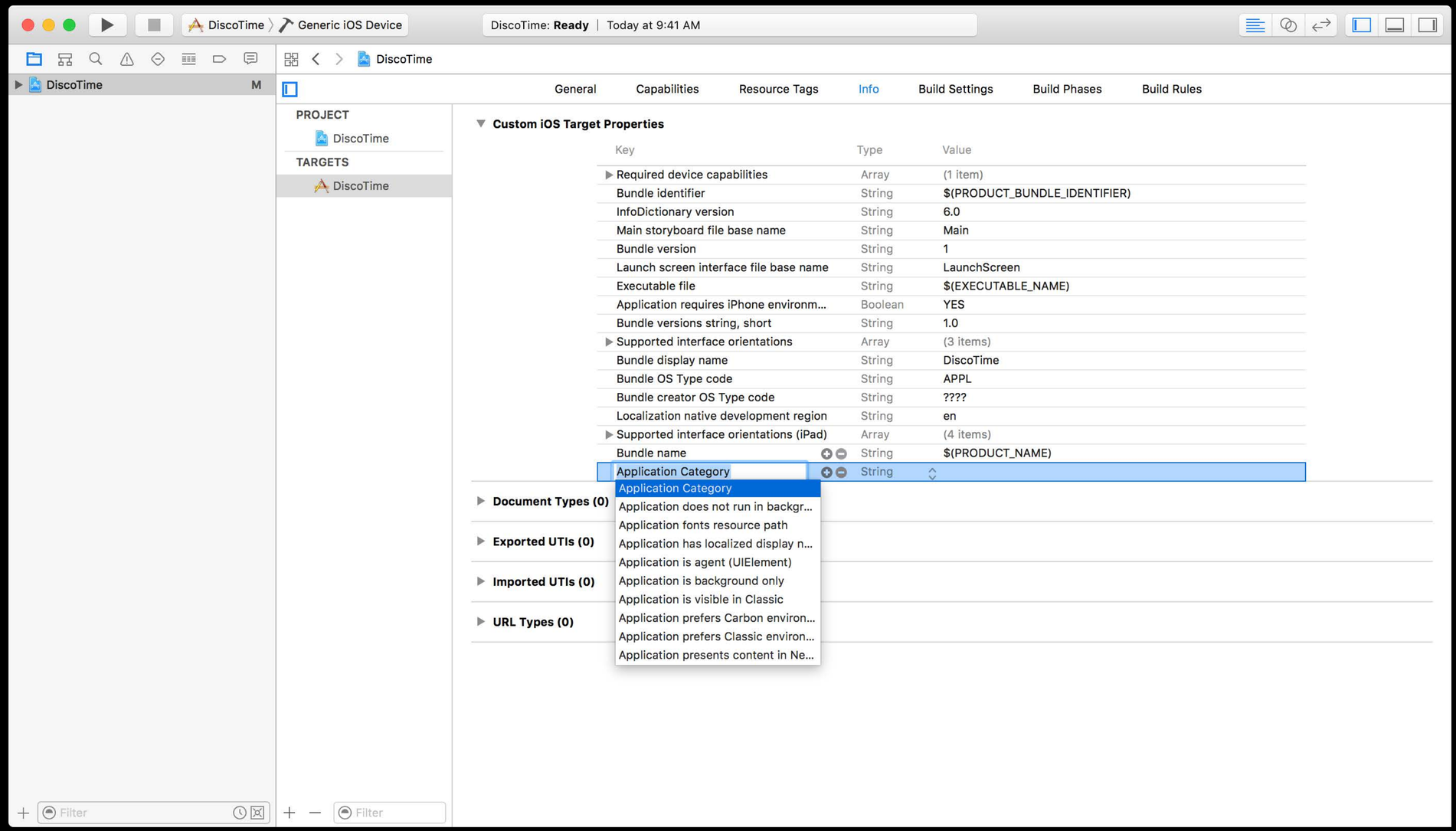

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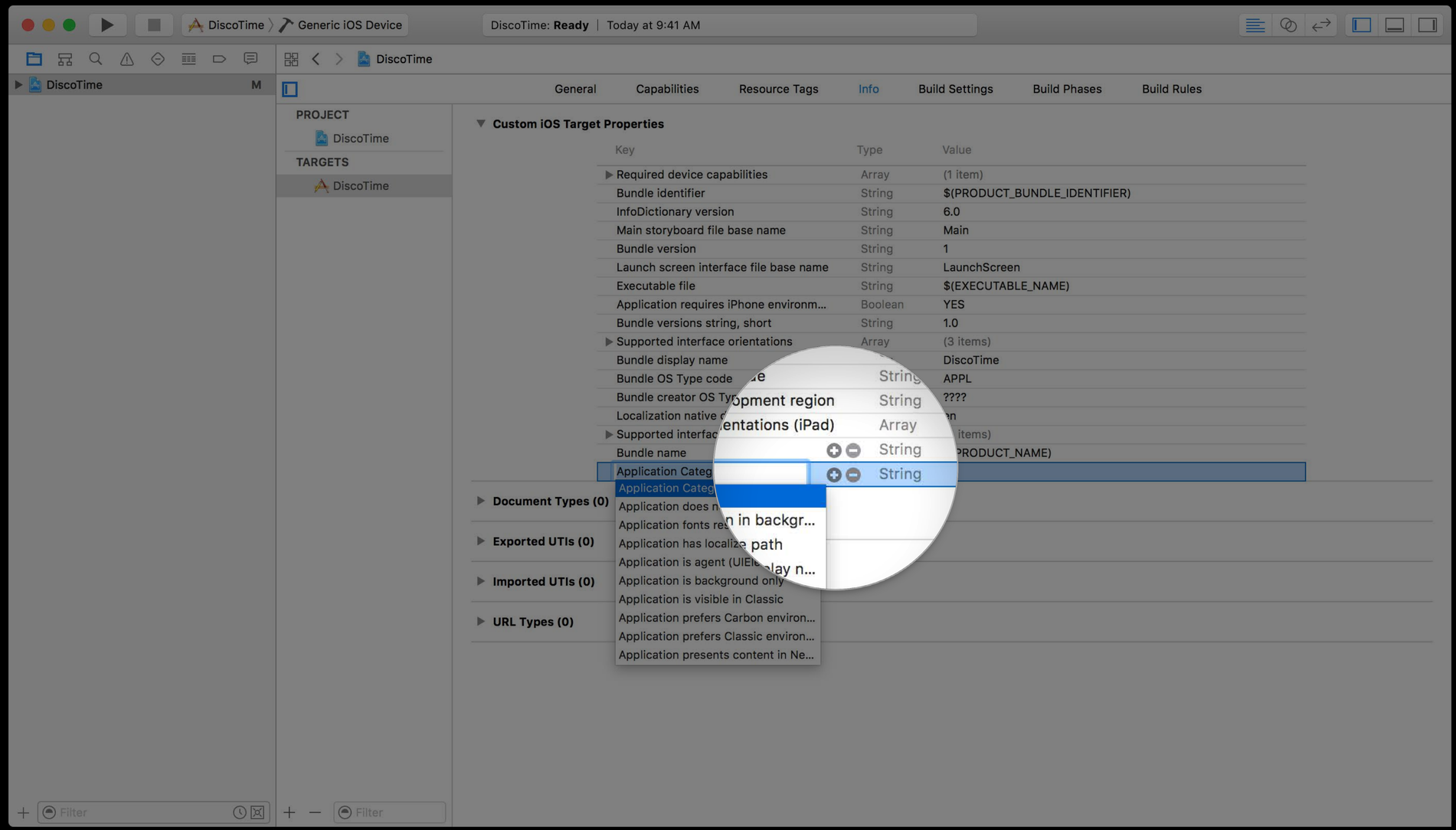
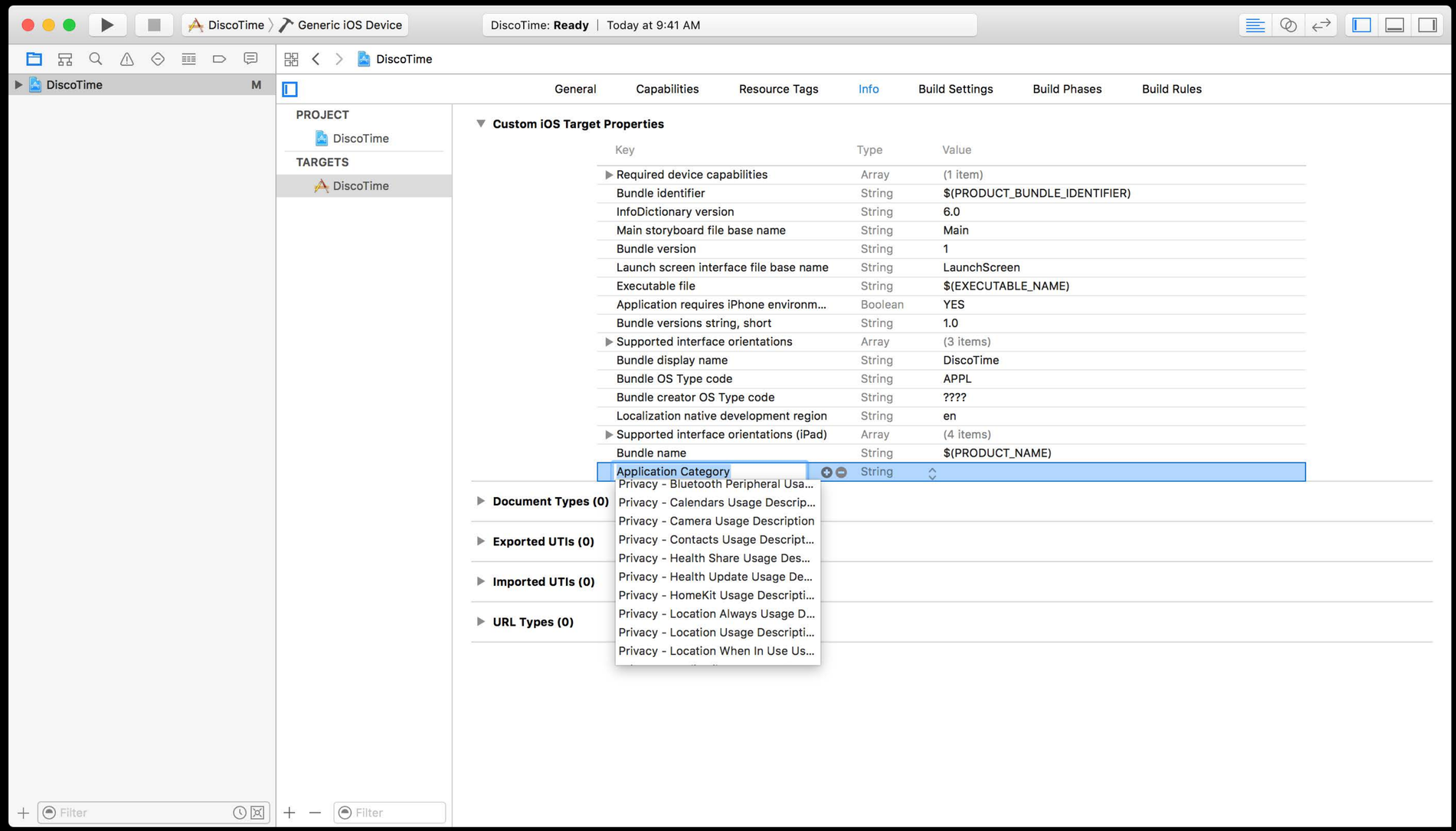
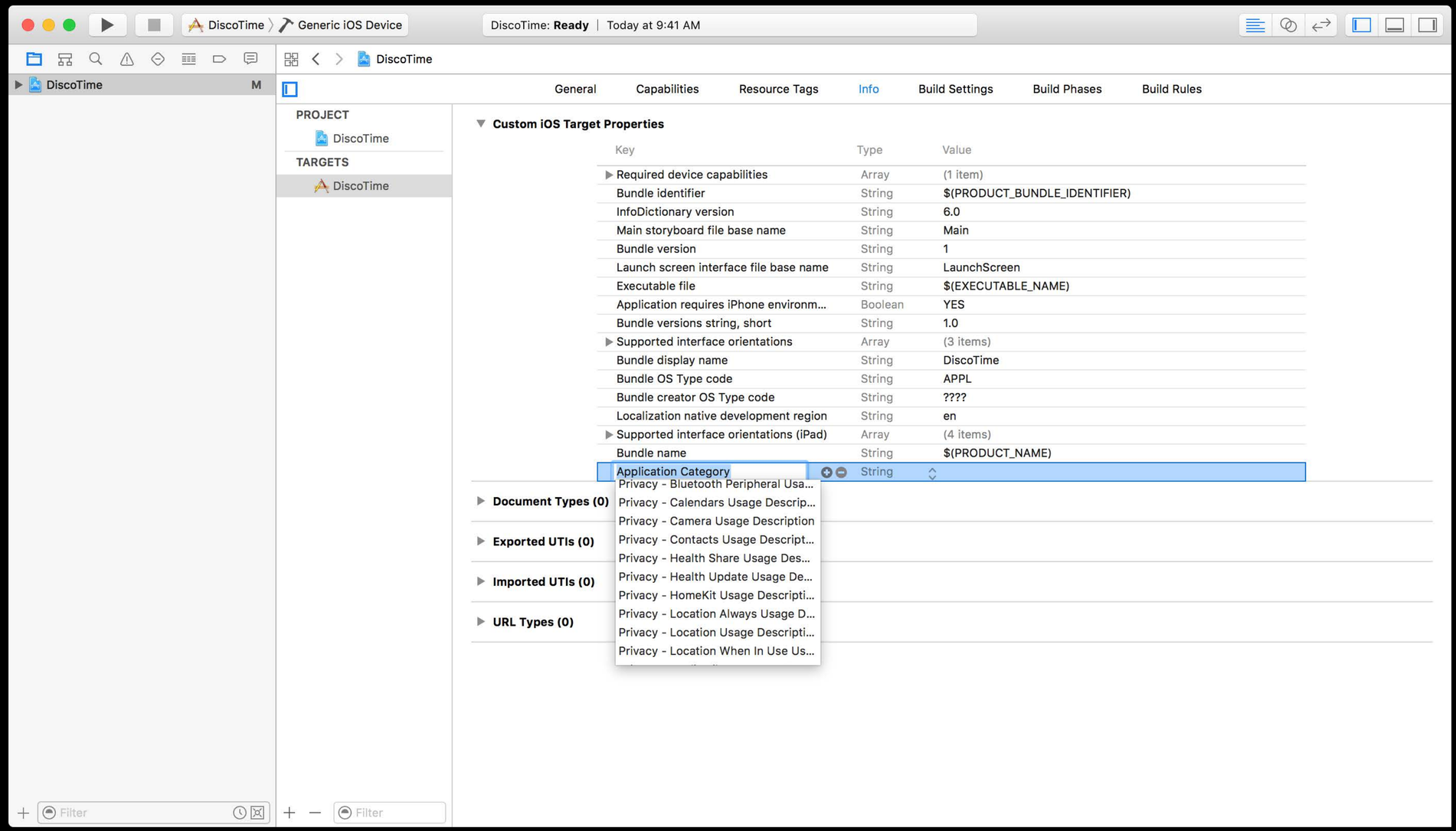


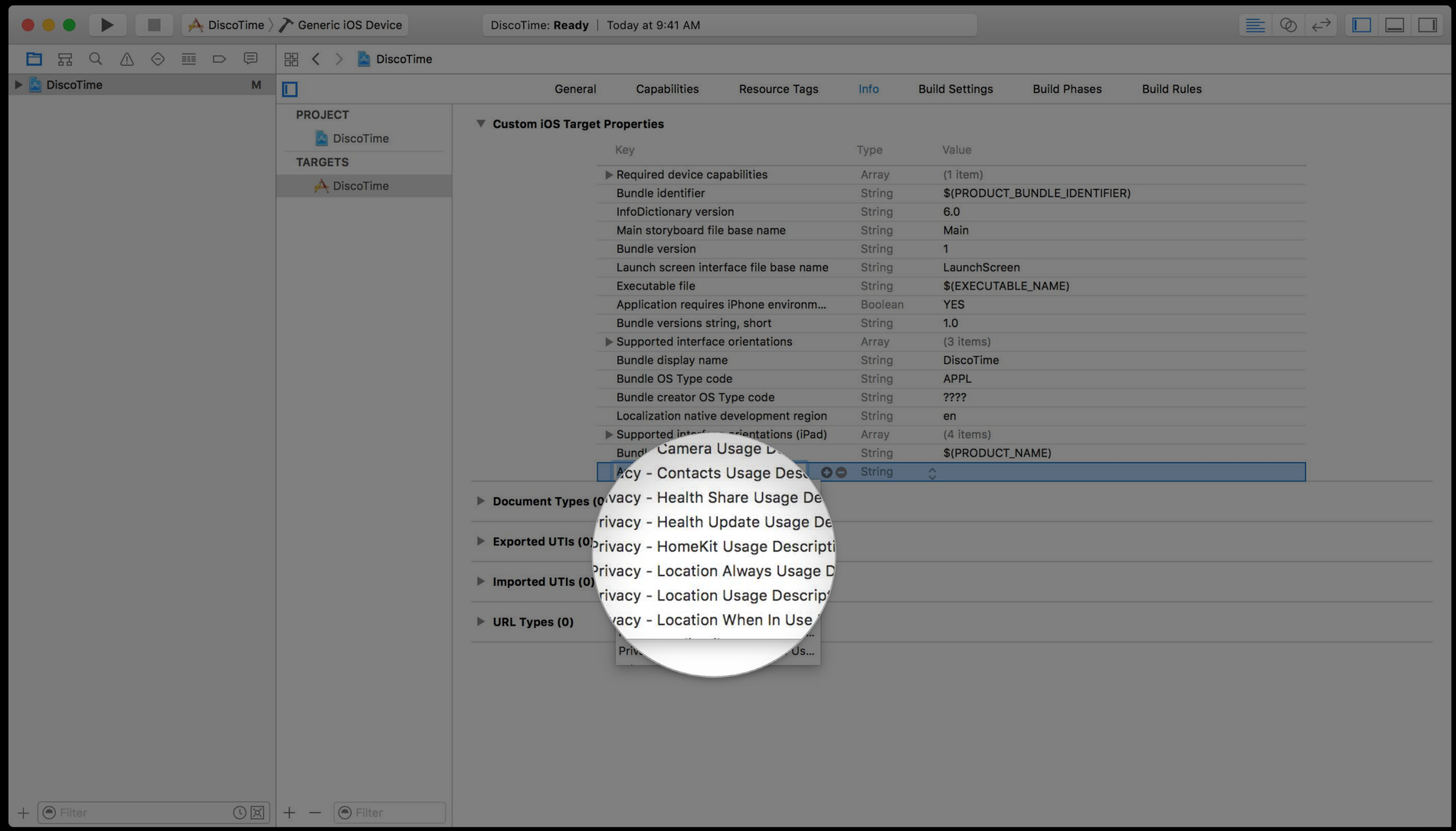
Add Purpose String in Xcode



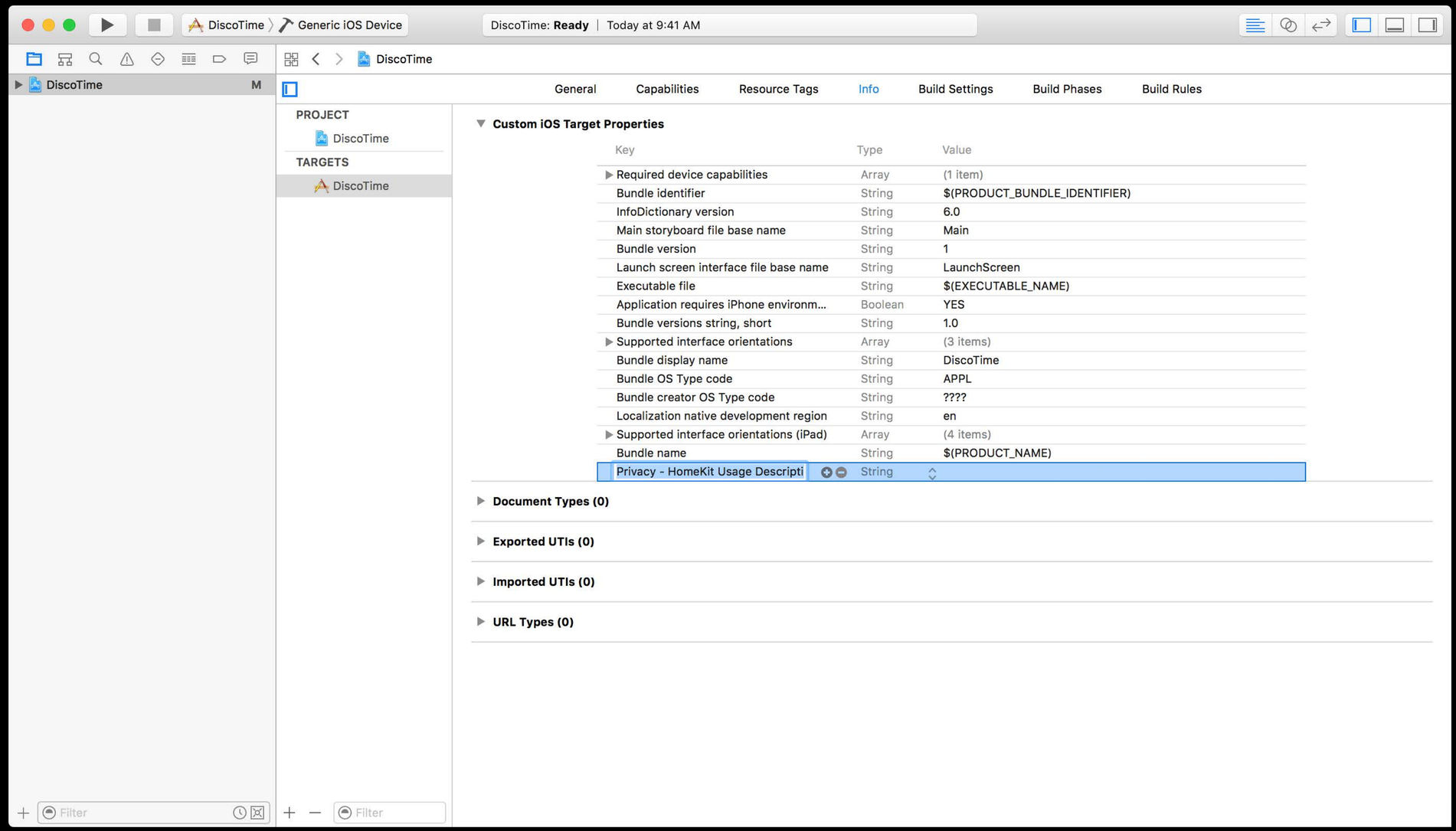
Add Purpose String in Xcode



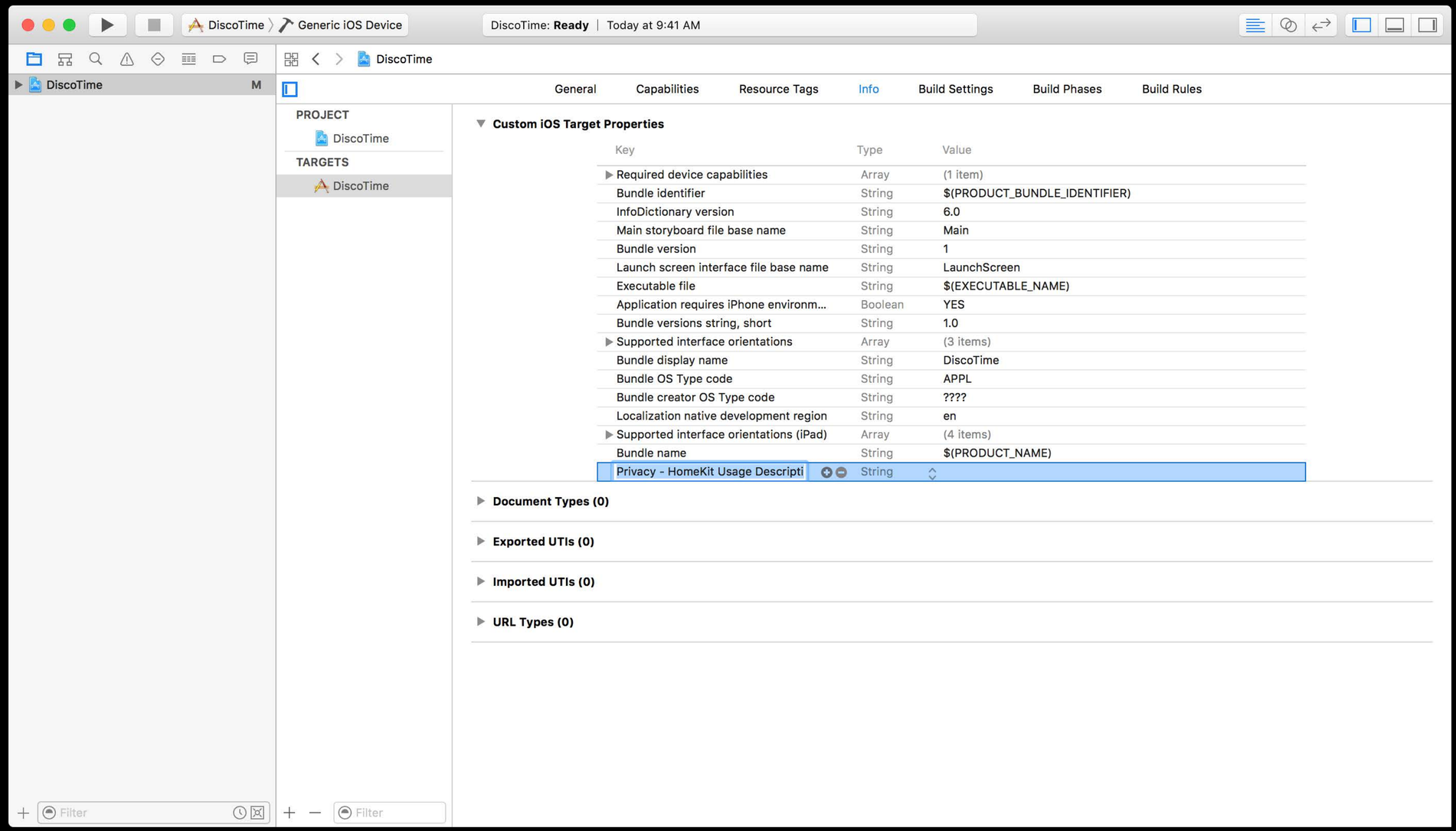
Add Purpose String in Xcode



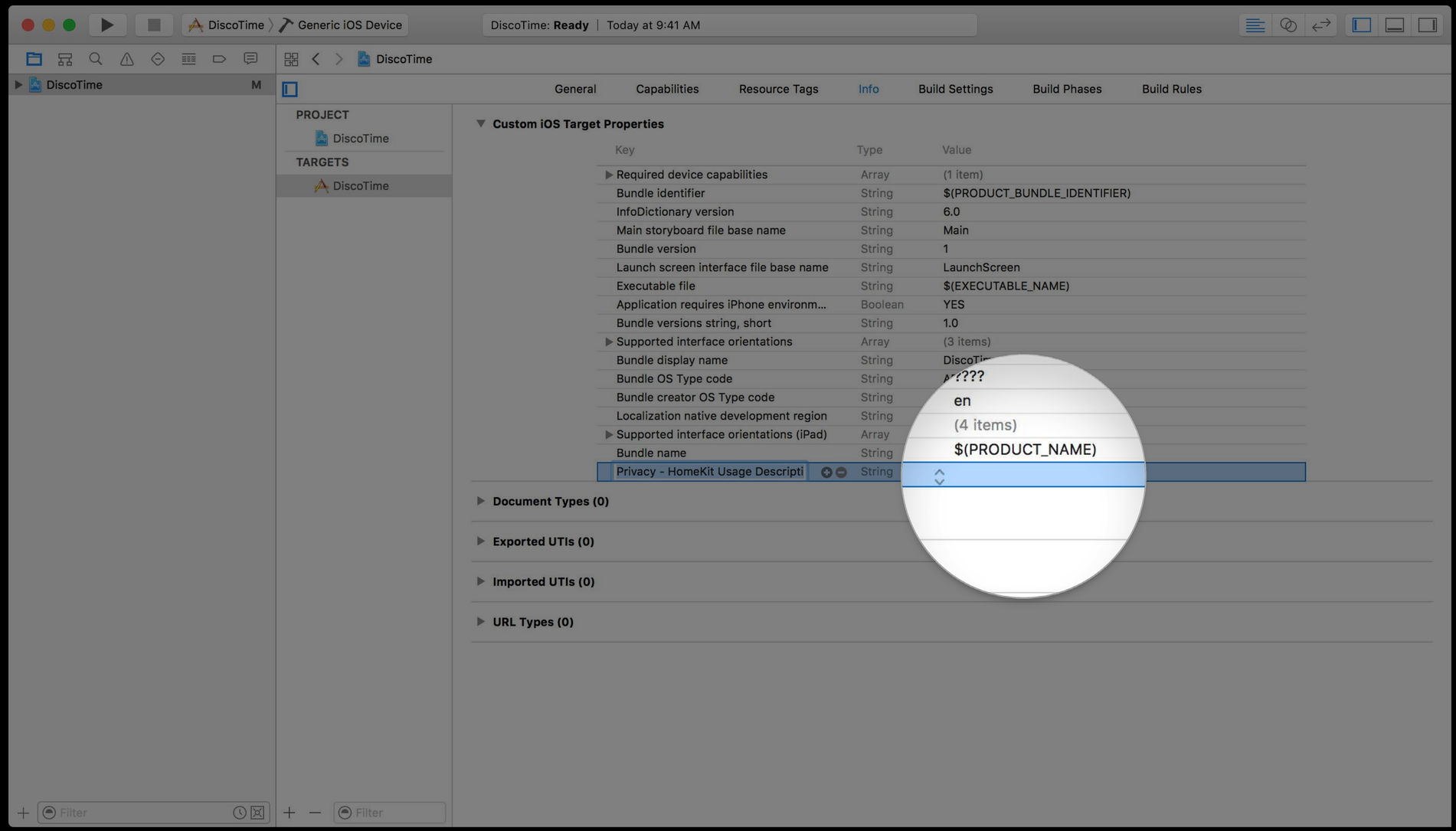
Add Purpose String in Xcode



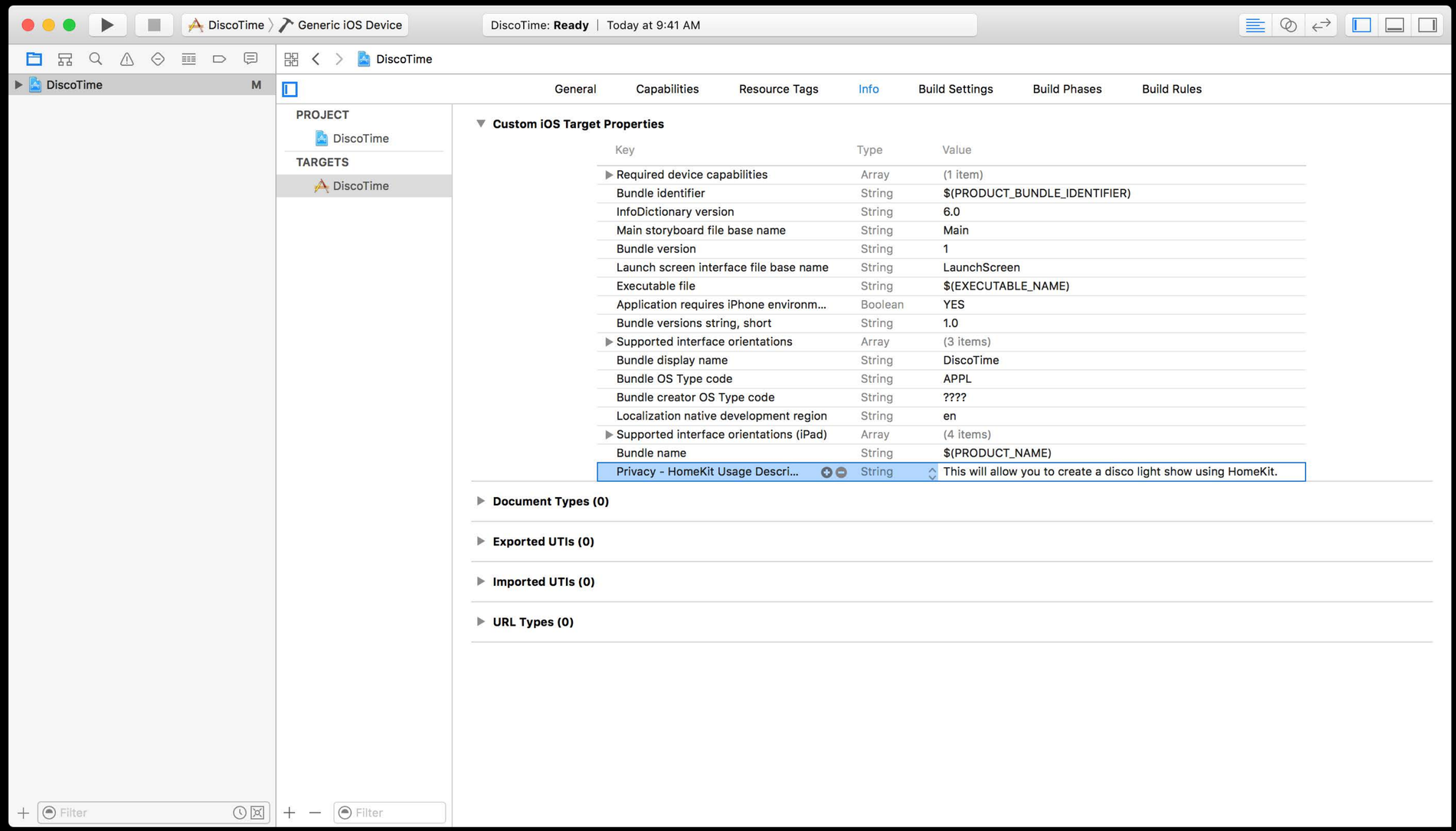
Add Purpose String in Xcode



Add Purpose String in Xcode



Add Purpose String in Xcode



If Not, You'll Crash and 🔥

If Not, You'll Crash and 🔥

```
2016-05-12 13:40:54.161036 DiscoTime[12103:588848]
This app has crashed because it attempted to
access privacy-sensitive data without a usage
description.  The app's Info.plist must contain an
NSHomeKitUsageDescription key with a string value
explaining to the user how the app uses this data.
```

What Does That Mean for You?

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New Features with Privacy Settings

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New Features with Privacy Settings

Declare Purpose String in info.plist

Building Privacy into Your App

Pasteboard Changes

iOS 10

NEW

Pasteboard Changes

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NEW

Set expiration and local options of pasteboards

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Set expiration and local options of pasteboards

```
@available(iOS 10.0, *)
enum UIPasteboardOption: String {
    case expirationDate
    case localOnly
}
```

Pasteboard Changes

Example

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```
var image: UIImage
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```
var image: UIImage
let pasteboard = UIPasteboard.general()
```

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Example

Set expiration and local options of pasteboards

```
var image: UIImage
let pasteboard = UIPasteboard.general()
pasteboard.setItems([{UIPasteboardTypeAutomatic: “Hello, world”},
```

Pasteboard Changes

NEW

Example

Set expiration and local options of pasteboards

```
var image: UIImage
let pasteboard = UIPasteboard.general()
pasteboard.setItems([{UIPasteboardTypeAutomatic: “Hello, world”},
                     {UIPasteboardTypeAutomatic: image}],
```

Pasteboard Changes

NEW

Example

Set expiration and local options of pasteboards

```
var image: UIImage
let pasteboard = UIPasteboard.general()
pasteboard.setItems([{UIPasteboardTypeAutomatic: “Hello, world”},
                     {UIPasteboardTypeAutomatic: image}],
                    options: {.expirationDate: Date(timeIntervalSinceNow: 120.0),
```

Pasteboard Changes

Example

NEW

Set expiration and local options of pasteboards

```
var image: UIImage
let pasteboard = UIPasteboard.general()
pasteboard.setItems([{UIPasteboardTypeAutomatic: “Hello, world”},
                     {UIPasteboardTypeAutomatic: image}],
                    options: {.expirationDate: Date(timeIntervalSinceNow: 120.0),
                              .localOnly: true})
```

Pasteboard Changes

iOS 10

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All named pasteboards will be defaulted to non-persistent

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The Find Pasteboard will yield an empty object

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All named pasteboards will be defaulted to non-persistent

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Use shared containers instead of named pasteboards

Core Spotlight Framework

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Every user tap should not result in NSUserActivity being published

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Every user tap should not result in NSUserActivity being published

Do not set eligibleForPublicIndexing to true if data is sensitive user data

Widgets

Widgets on Home screen

Widgets on Lock screen

Widgets on Lock Screen

Widgets on Lock Screen

Evaluate sensitivity of data in widgets

Widgets on Lock Screen

Evaluate sensitivity of data in widgets

Consistent and predictable data

Widgets on Lock Screen

Evaluate sensitivity of data in widgets

Consistent and predictable data

Data that is FileProtectionType.complete will not be available

Find my Friends widget

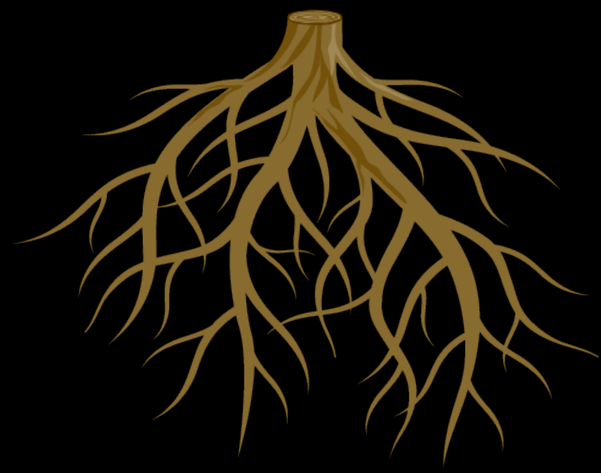
Find my Friends widget

Find my Friends widget

Summary

Summary

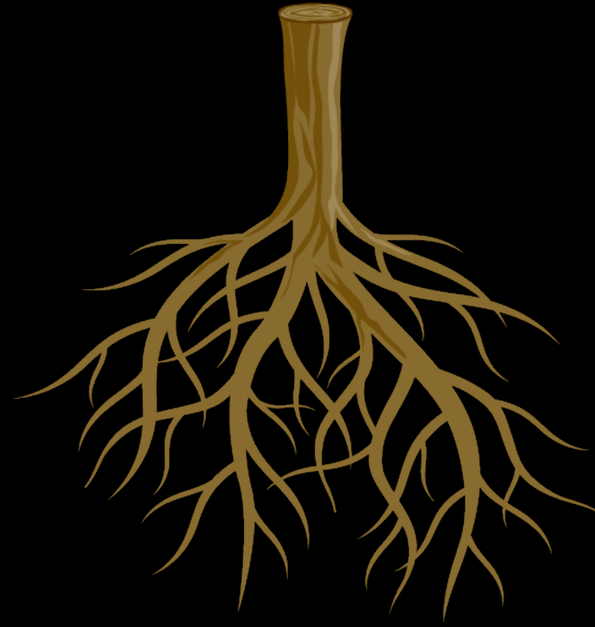
Favor short-lived identifiers



Summary

Favor short-lived identifiers

Collect data in privacy friendly ways



Summary

Favor short-lived identifiers

Collect data in privacy friendly ways

Increase transparency and control
to gain user trust

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Increase transparency and control to gain user trust

Empower users to make good privacy decisions

Summary

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Collect data in privacy friendly ways

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Empower users to make good privacy decisions

Use new tools to build privacy into your app

More Information

https://developer.apple.com/wwdc16/709

Related Sessions

How iOS Security Really Works	Nob Hill	Tuesday 4:00PM
What's New in Security	Nob Hill	Tuesday 5:00PM
Core Location Best Practices	Pacific Heights	Thursday 4:00PM

Labs

Security & Privacy Lab 1	Frameworks Lab C	Wednesday 9:00AM
Security & Privacy Lab 2	Frameworks Lab B	Thursday 9:00AM

WWDC16