LEARNING FROM IOS ANIMATIONS

Justin Miller • Mapbox

The animation foundations in iOS are well-designed, intuitive, and powerful.

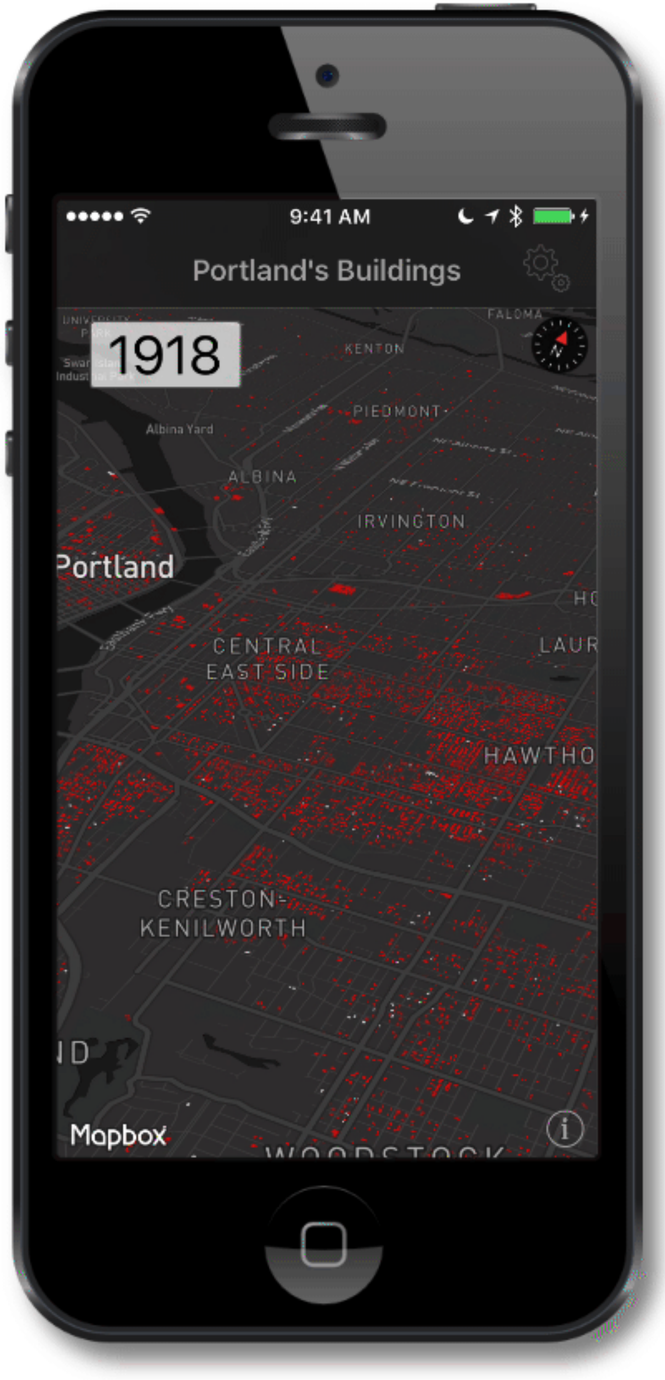
What can we learn about how they are built, the capabilities that they give, and the assumptions that they are built upon, that we can bring to our own software design?

PERSONAL INTRO

- I've been programming for work for 20 years & have been using Apple technologies for 15 of those
  - Perl, PHP, Objective-C, C, C++, Java, Swift (also Bash)
- I've been both an app builder and a tool builder
- I have always admired Apple's API design

MAPBOX INTRO

- We're building developer tools for maps & location
  - Customized map appearance & function
- We recently added "runtime styling"
- I have had to think a lot lately about animations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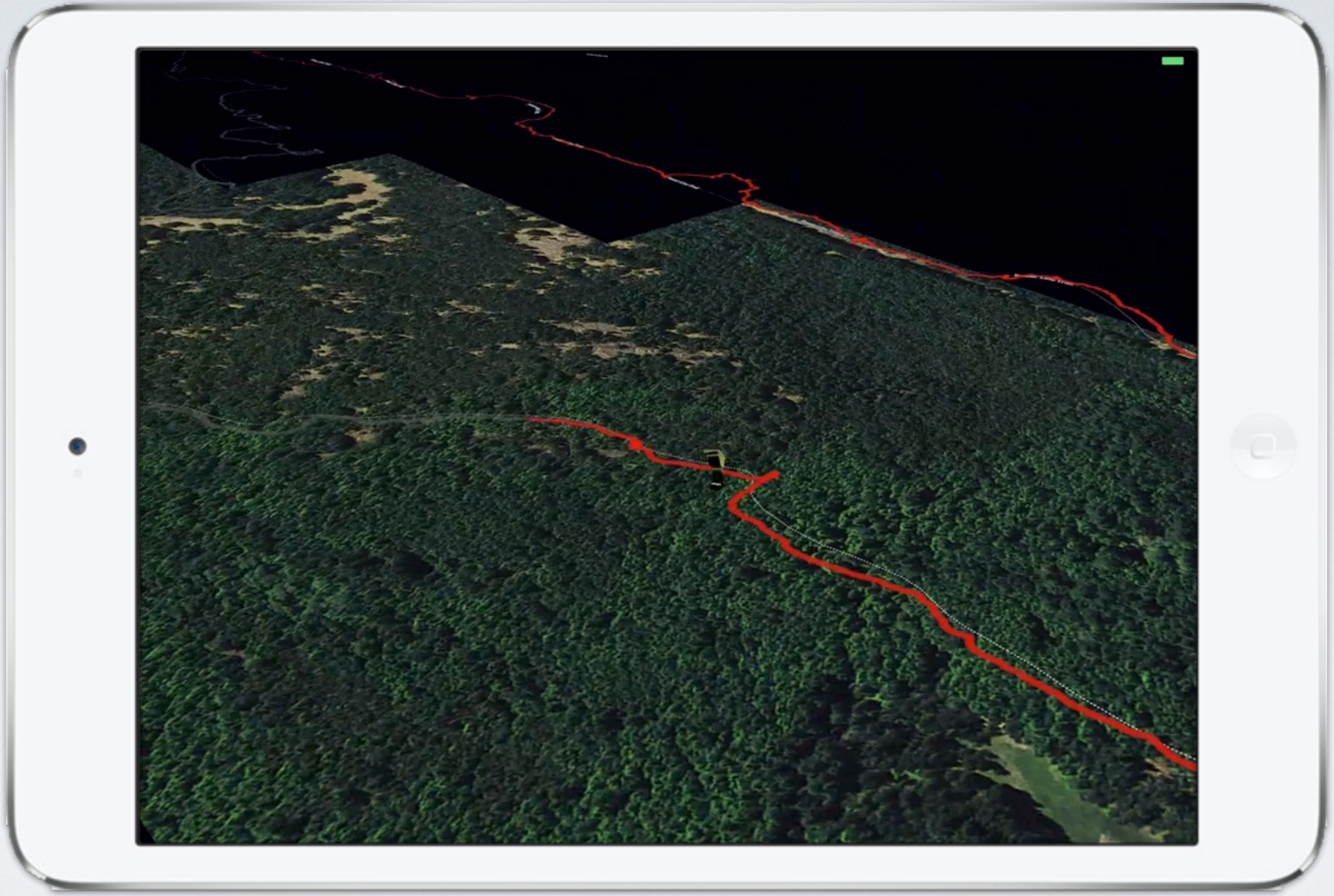
Portland's Buildings
1918
KENTON
PIEDMONT
Albina Yard
ALBINA
IRVINGTON
Portland
CENTRAL
EAST SIDE
CRESTON-
KENILWORTH
Mapbox

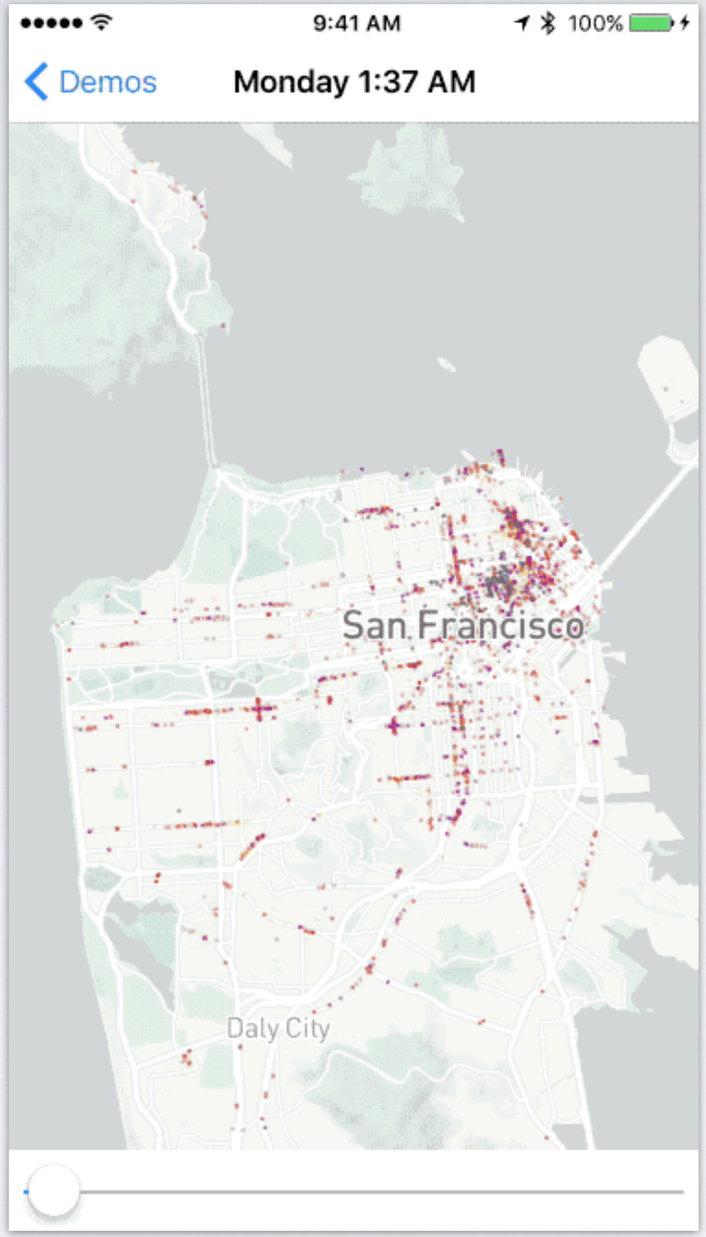
9:41 AM
Portland's Buildings
1935
WILLAMETTE HEIGHTS
KINGS HEIGHTS
UNIVERSITY DISTRICT
Portland
CENTRAL EAST SIDE
SE Division St
SE 52nd Ave
Mapbox

9:41 AM
Portland's Buildings
1964
LANDING
STMORELAND
Ross Island
BROOKLYN
CRESTON-
KENILWORTH
Mapbox

Power Line Trail
Power Line Trail

9:41 AM
KAFE-FM
KLYN-FM

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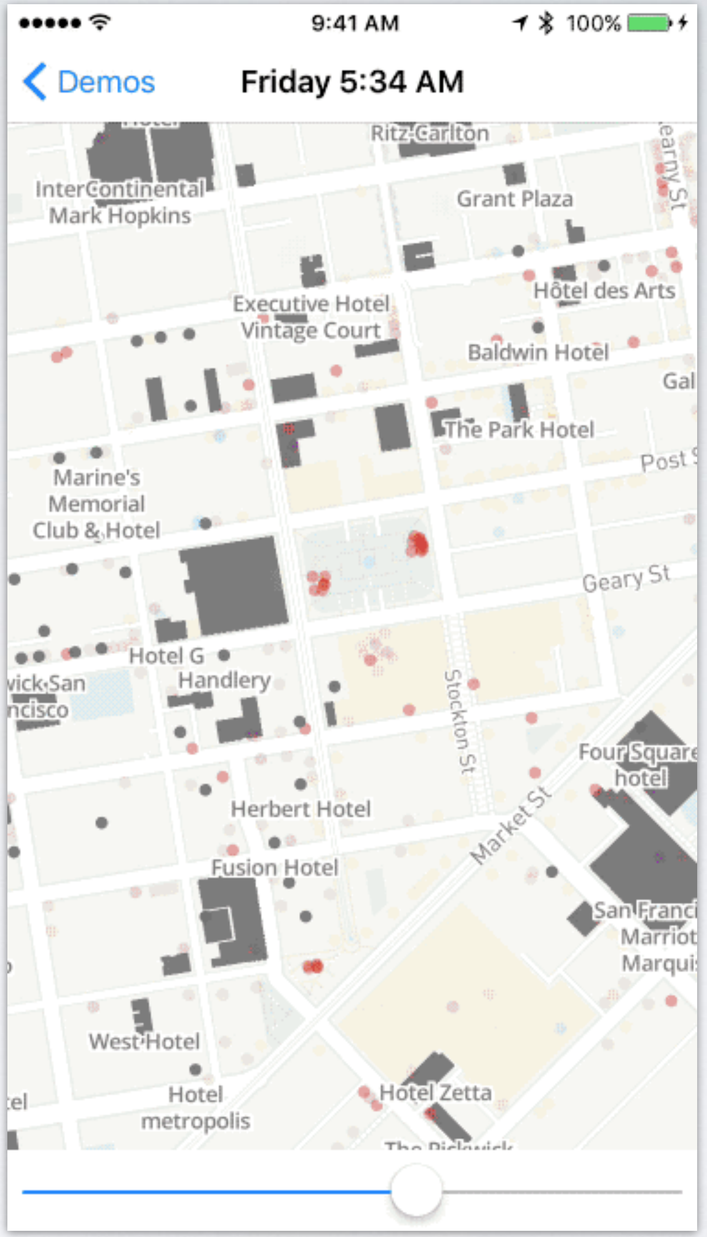
Demos
Monday 1:37 AM
San Francisco
Daly City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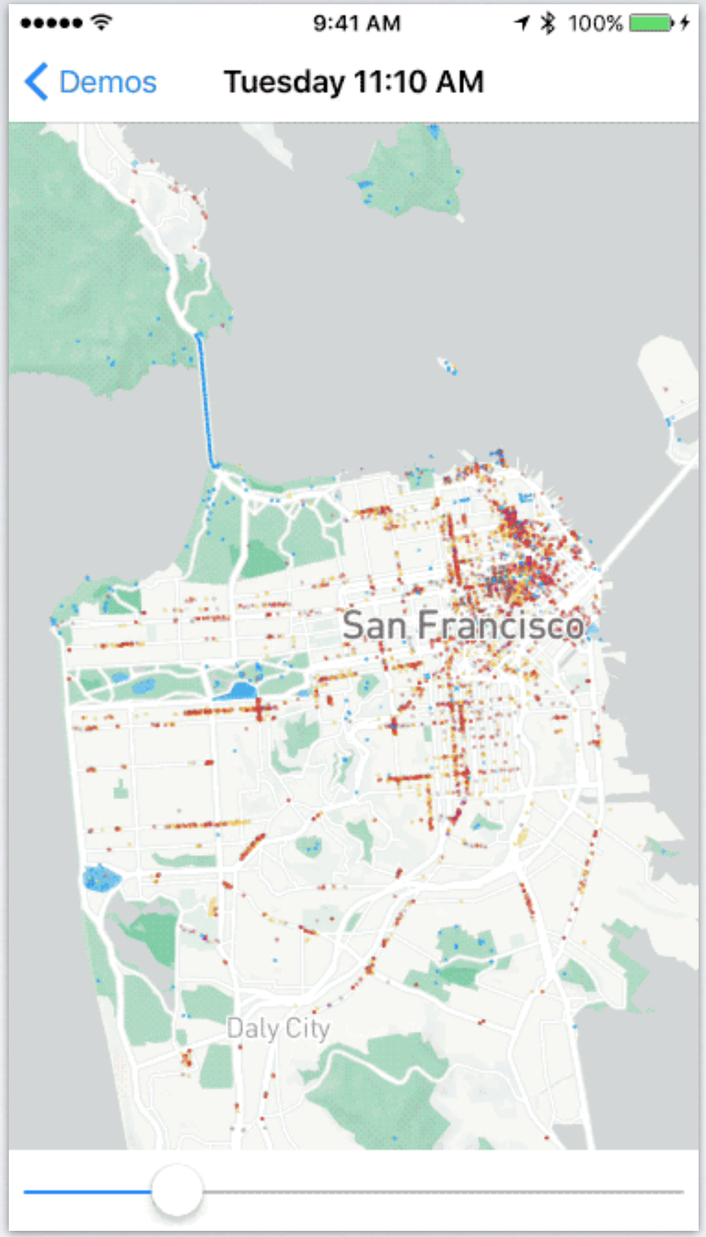
Friday 5:34 AM
Ritz-Carlton
InterContinental
Mark Hopkins
Grant Plaza
Hôtel des Arts
Executive Hotel
Vintage Court
Baldwin Hotel
The Park Hotel
Marine's
Memorial
Club & Hotel
Geary St
Hotel G
Handlery
Stockton St
Four Square
hotel
Herbert Hotel
Market St
Fusion Hotel
West Hotel
Hotel
metropolis
Hotel Zetta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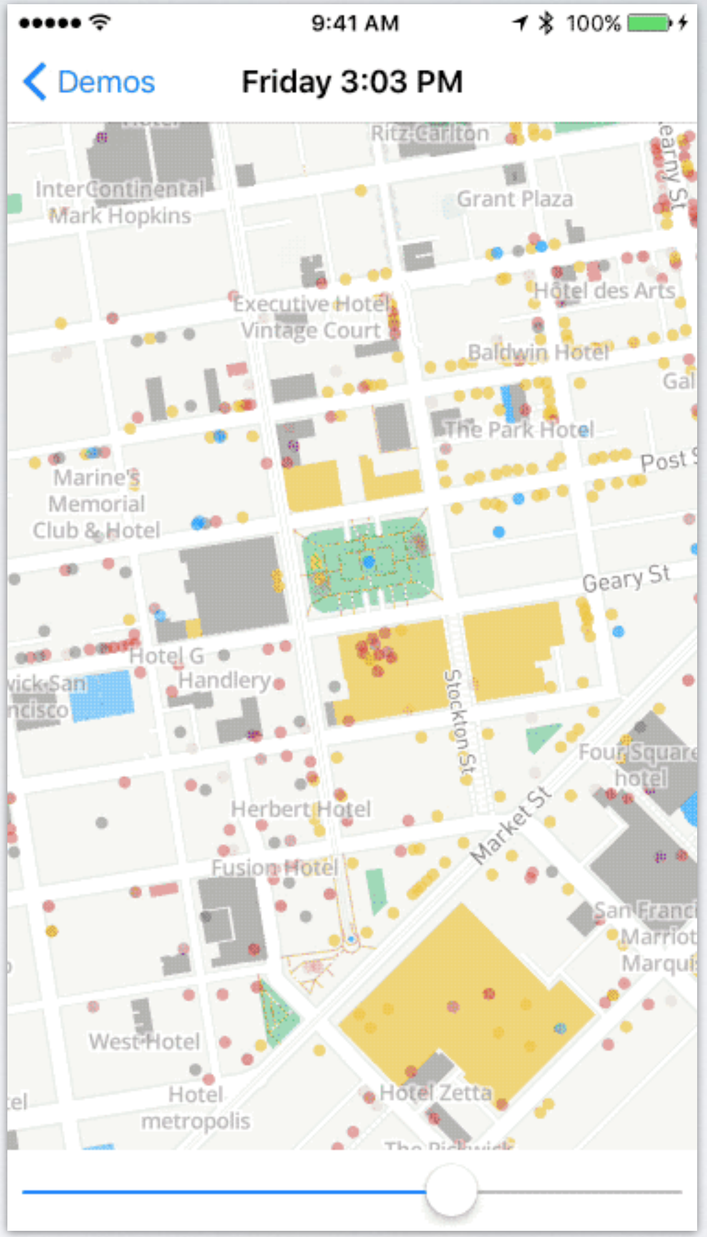
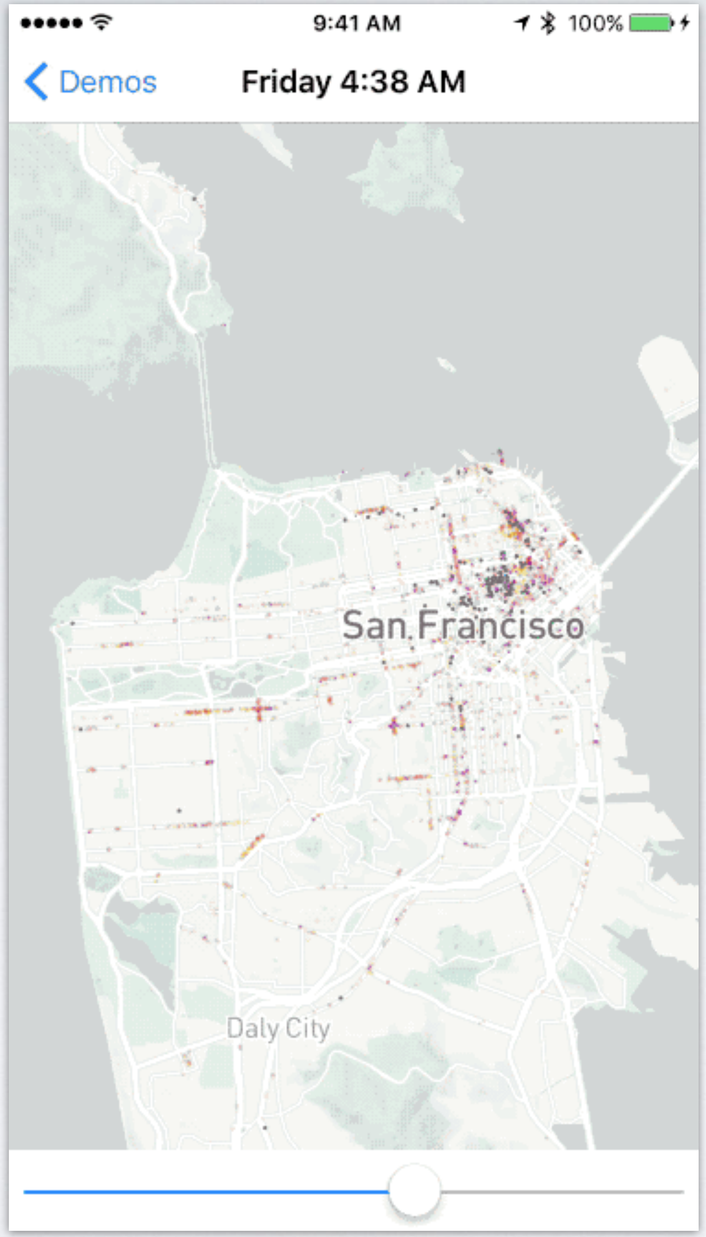

9:41 AM
100%
Demos
Friday 3:03 PM
Ritz-Carlton
InterContinental Mark Hopkins
Grant Plaza
Hotel des Arts
Executive Hotel Vintage Court
Baldwin Hotel
The Park Hotel
Marine's Memorial Club & Hotel
Geary St
Hotel G
Handlery
Stockton St
Four Square hotel
Herbert Hotel
Market St
Fusion Hotel
West Hotel
Hotel metropolis
Hotel Zetta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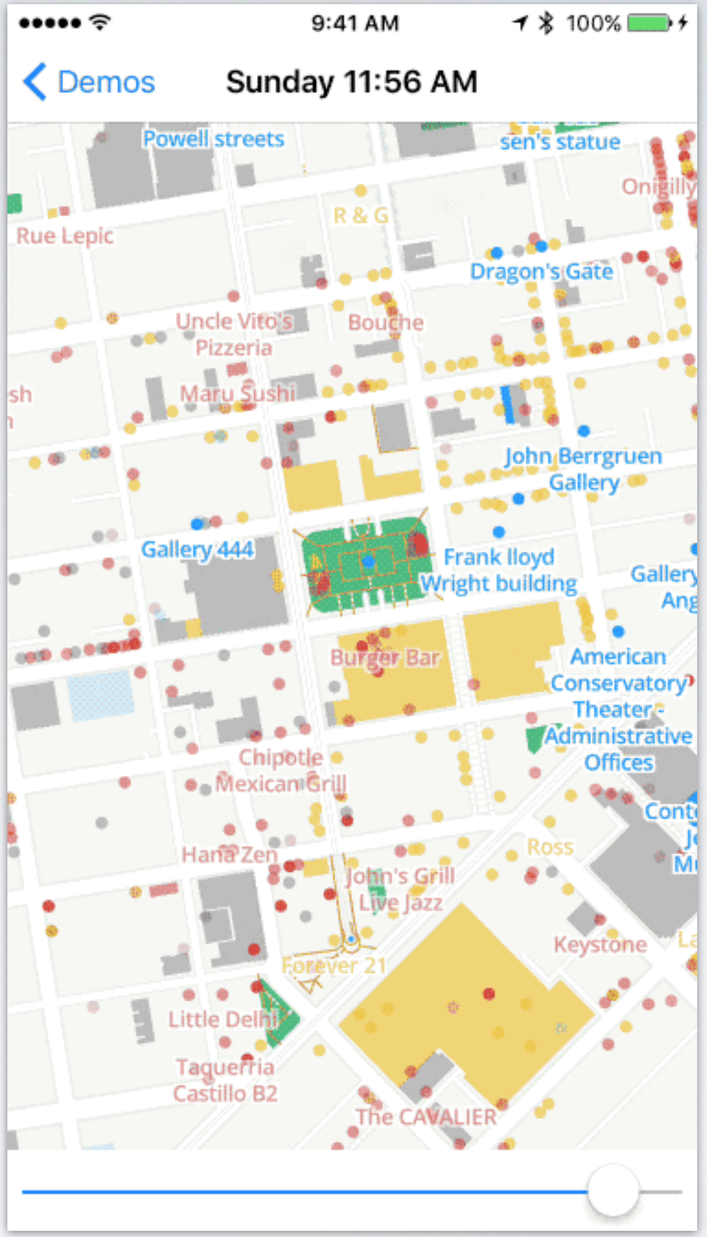
Demos
Friday 4:38 AM
San Francisco
Daly City


9:41 AM
100%
Demos
Sunday 11:56 AM
Powell streets
sen's statue
Rue Lepic
R & G
Dragon's Gate
Uncle Vito's Pizzeria
Bouche
Maru Sushi
John Berrgruen Gallery
Gallery 444
Frank lloyd Wright building
Burger Bar
American Conservatory Theater - Administrative Offices
Chipotle Mexican Grill
Hana Zen
John's Grill Live Jazz
Ross
Keystone
Forever 21
Little Delhi
Taqueria Castillo B2
The CAVALIER

WHAT ARE ANIMATIONS?

TI-99/4A
color monitor
TEXAS INSTRUMENTS
HOME COMPUTER
READY-PRESS ANY KEY TO BEGIN
©1979 TEXAS INSTRUMENTS

MR. BOJANGLES

Bill "Bojangles" Robinson, 1878-1949

MR. BOJANGLES

- Probably the first programming that I can remember
- Intro to animation for the TI-99/4A computer (1979)
- Absolute simplest possible animation
  - Two frames swapped in time, coincident in position

CHAR Worksheet

First Figure

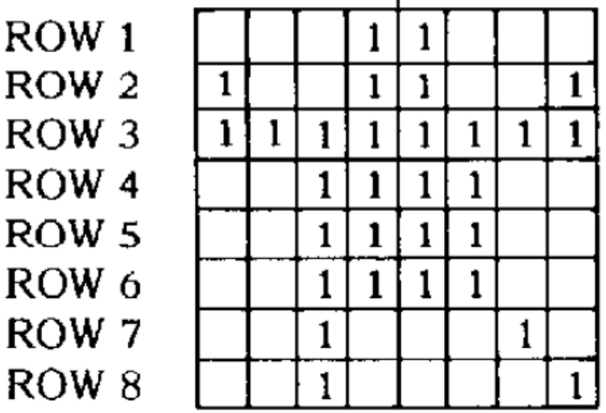
	LEFT BLOCK			RIGHT BLOCK				CODE
ROW 1	1			1	1			1	99
ROW 2		1		1	1		1		5A
ROW 3			1	1	1	1			3C
ROW 4			1	1	1	1			3C
ROW 5			1	1	1	1			3C
ROW 6			1	1	1	1			3C
ROW 7		1				1			44
ROW 8	1					1			84

INPUT TO CHAR: "995A3C3C3C3C4484"

SHORT-HAND CODE	DOTS
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
A	1010
B	1011
C	1100
D	1101
E	1110
F	1111

CHAR Worksheet

Second Figure

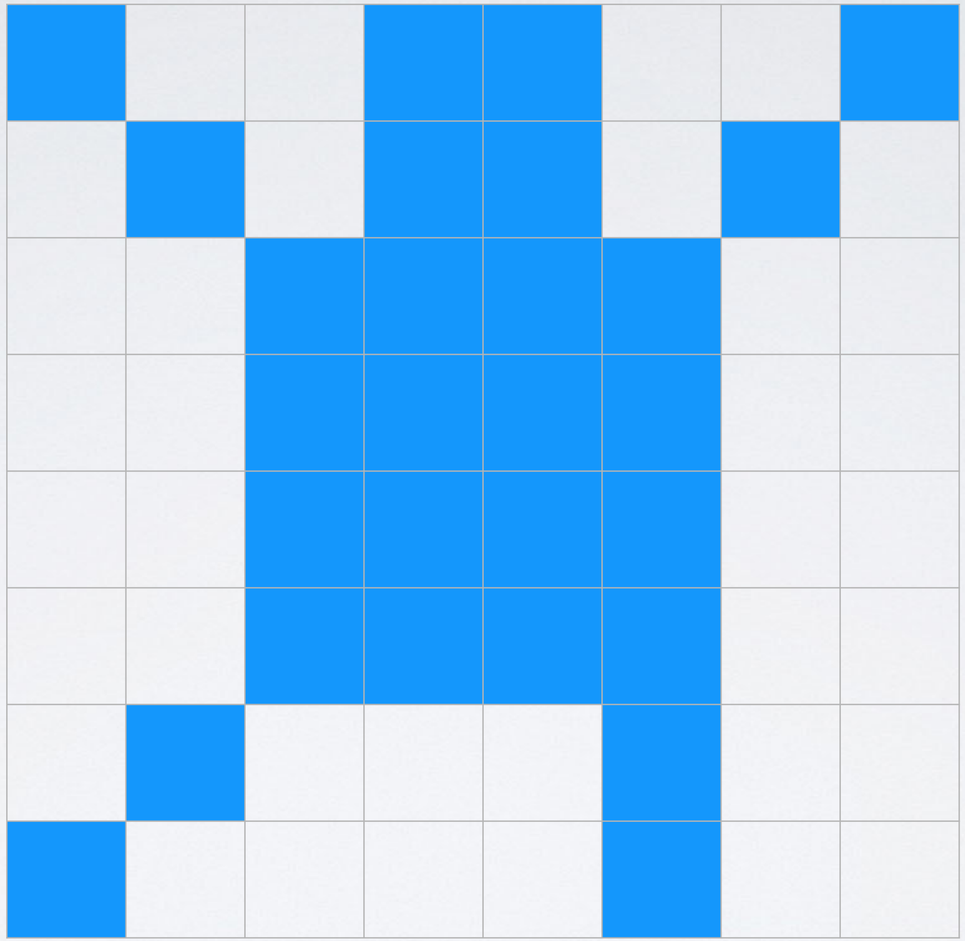


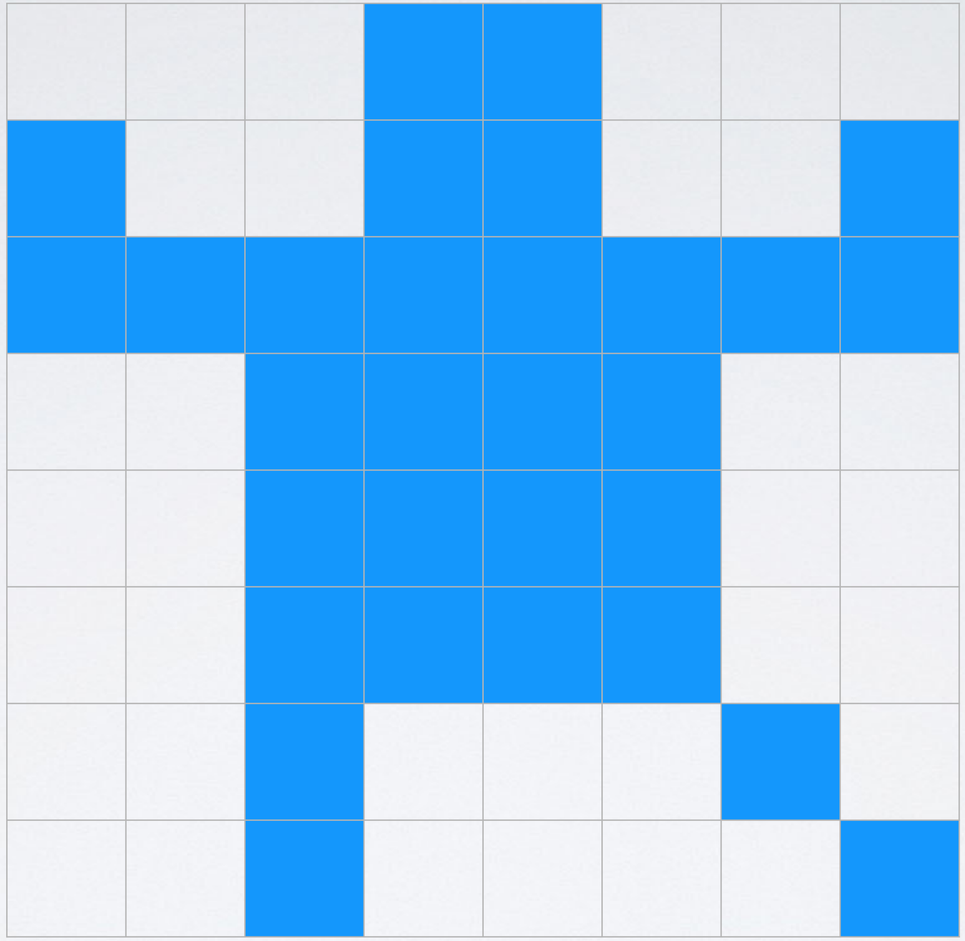
	LEFT BLOCK			RIGHT BLOCK				CODE
ROW 1				1	1				18
ROW 2	1			1	1			1	99
ROW 3	1	1	1	1	1	1	1	1	FF
ROW 4			1	1	1	1			3C
ROW 5			1	1	1	1			3C
ROW 6			1	1	1	1			3C
ROW 7			1				1		22
ROW 8			1					1	21

INPUT TO CHAR: "1899FF3C3C3C2221"

SHORT-HAND CODE	DOTS
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
A	1010
B	1011
C	1100
D	1101
E	1110
F	1111

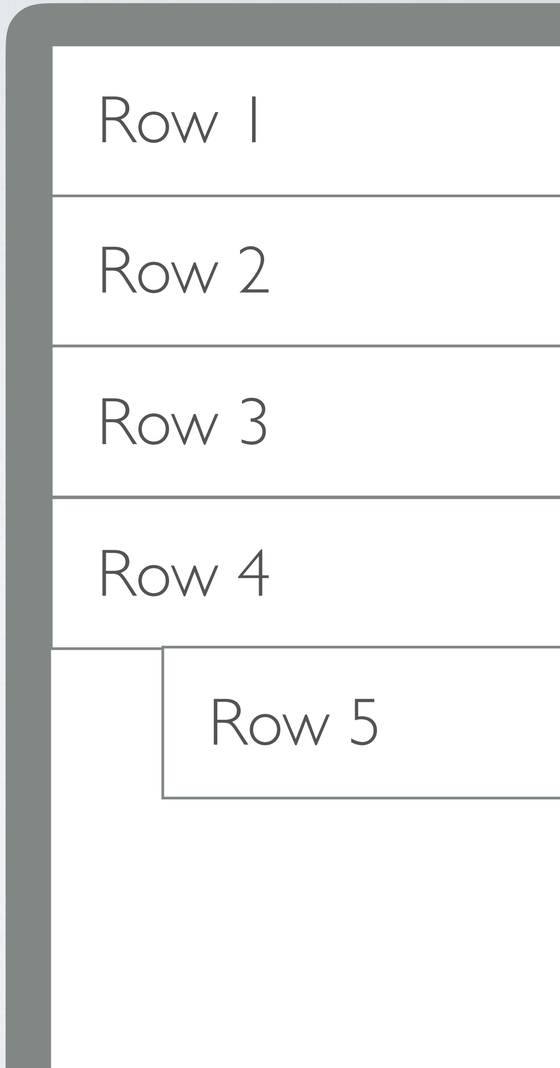
```
LIST
10 CALL CLEAR
20 A$="995A3C3C3C3C4484"
25 B$="1899FF3C3C3C2221"
30 CALL CHAR(128,A$)
35 CALL CHAR(129,B$)
40 CALL COLOR(13,2,16)
50 CALL VCHAR(12,16,128)
60 FOR DELAY=1 TO 100
70 NEXT DELAY
80 CALL VCHAR(12,16,129)
90 FOR DELAY=1 TO 100
100 NEXT DELAY
110 GOTO 50
```





ANIMATIONS ARE COMMUNICATION

- Hello, friends!
- Merhaba, arkadaşlar!
- We can tell the user with text
- Or we can show the user with animation



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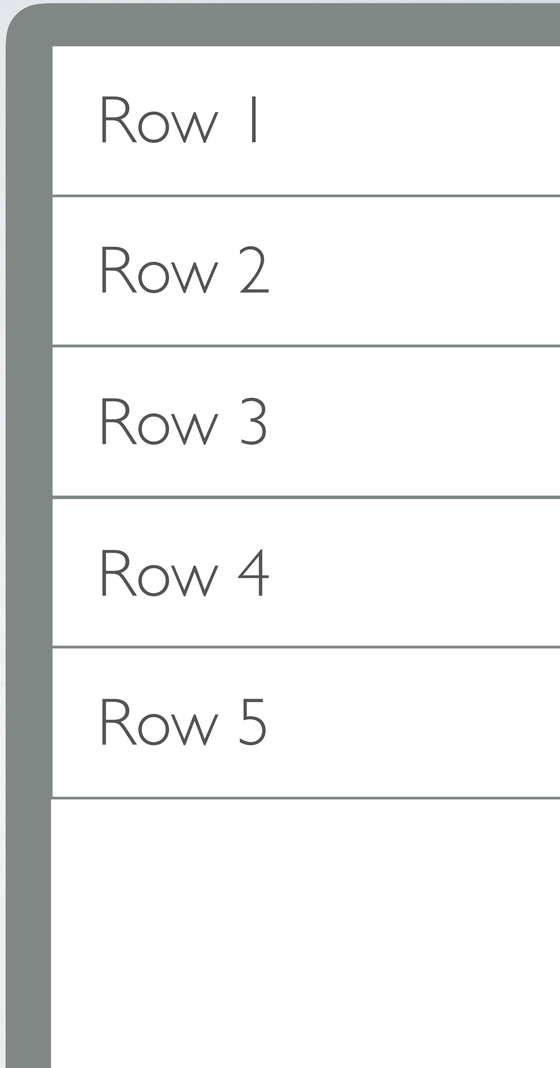


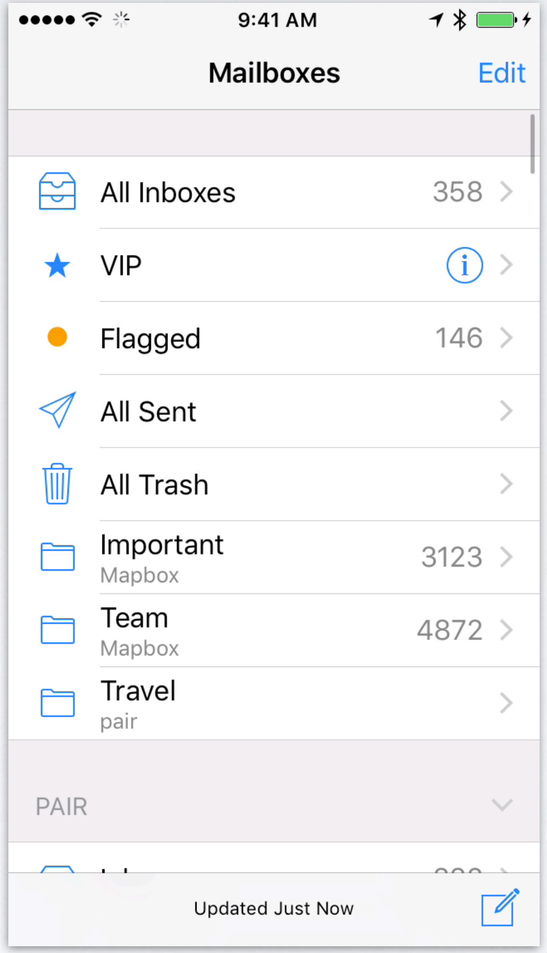
IOS ANIMATION PLATFORM

- I've focused on iOS due to its high performance and obsession with 60FPS
- Mature animation API which debuted for macOS (OS X) and was there from the start for iOS

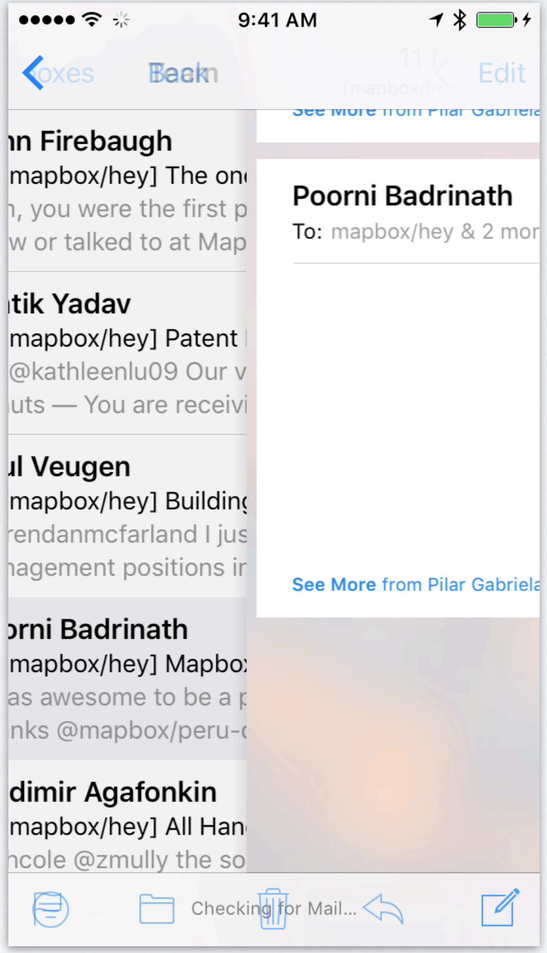
IOS ANIMATIONS ARE PERVASIVE

- You might not even notice many places that they happen
- But they are used through the base OS to give a sense of place, context, and movement

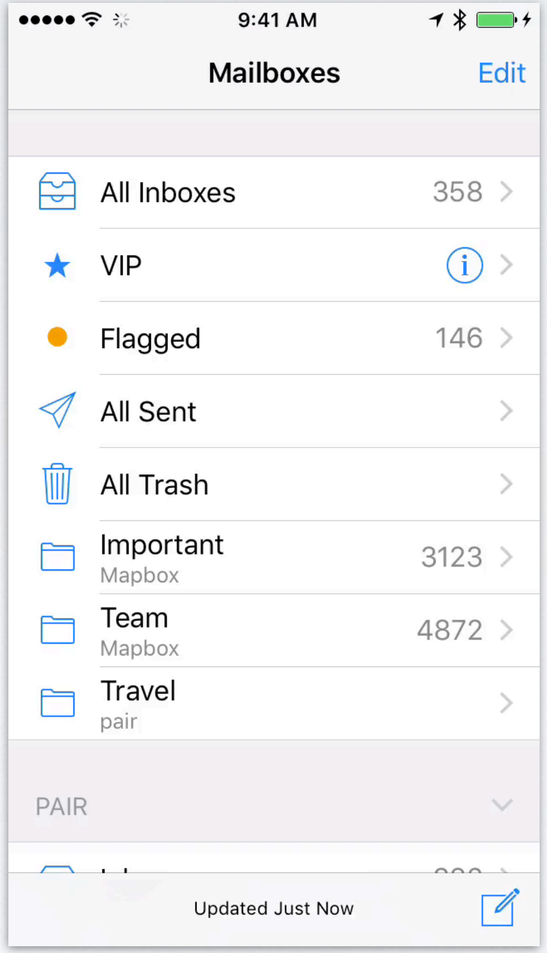
APP NAVIGATION



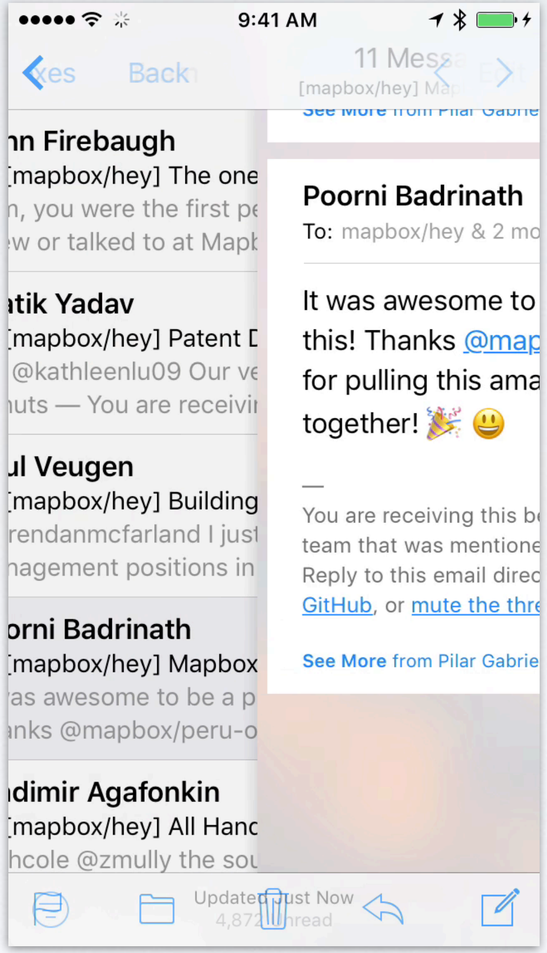
APP NAVIGATION



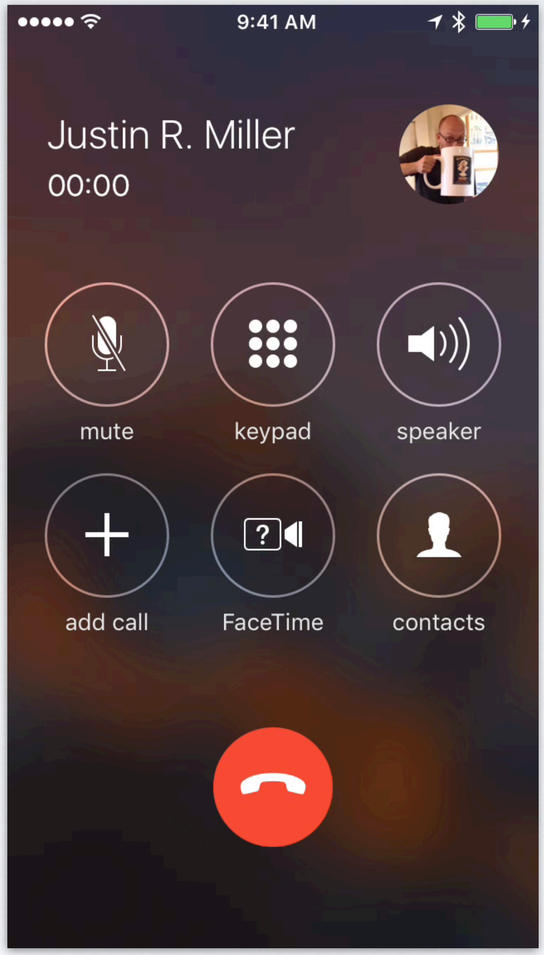
APP NAVIGATION



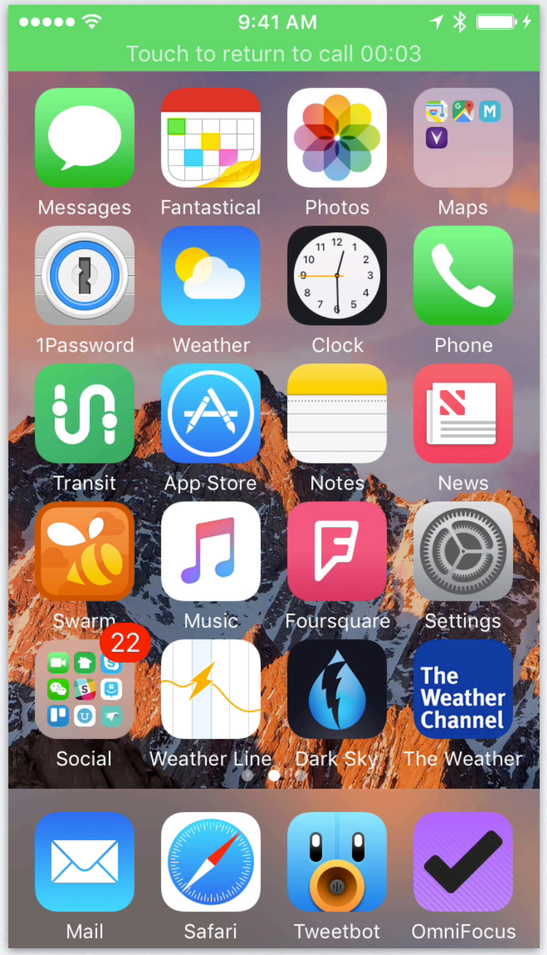
APP NAVIGATION



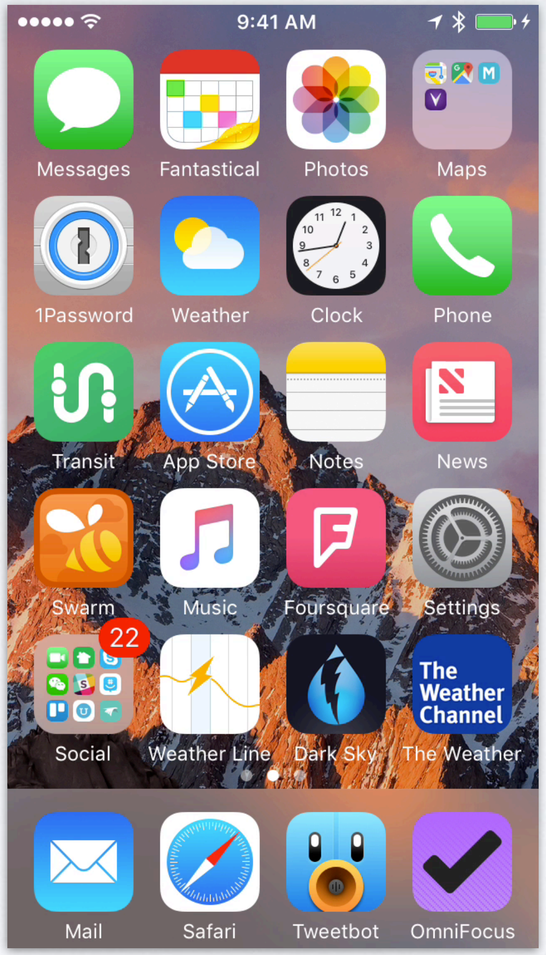
INDICATING MOTION OR ACTIVITY



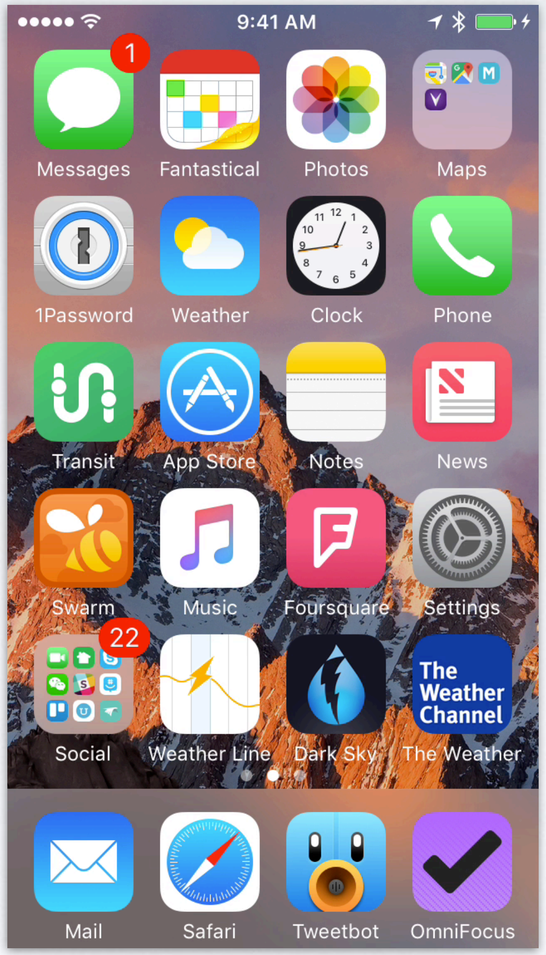
INDICATING MOTION OR ACTIVITY



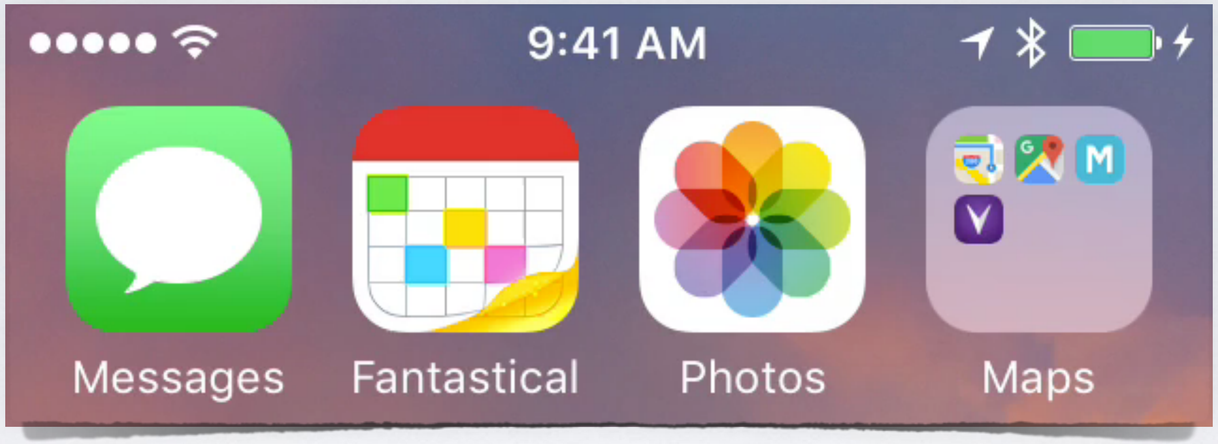
SOFTENING ROUTINES



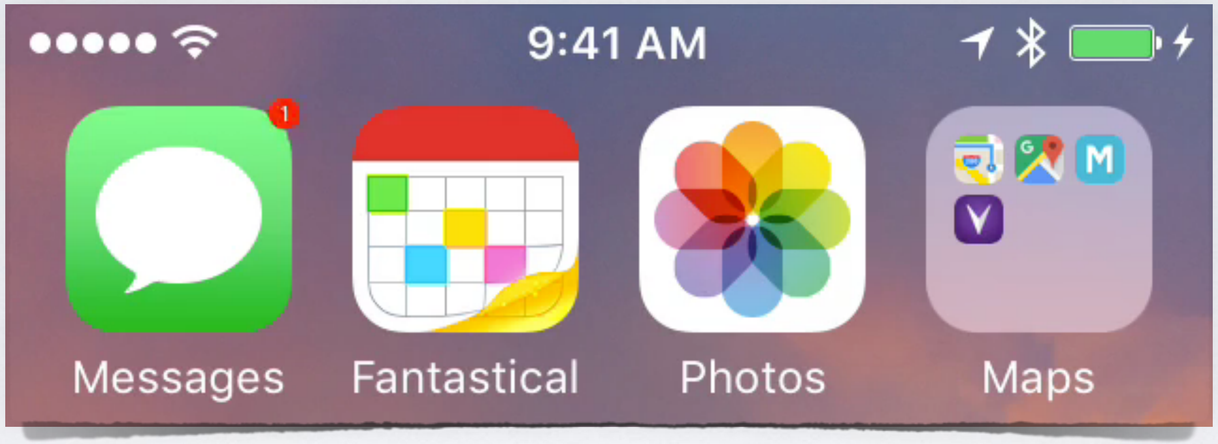
SOFTENING ROUTINES



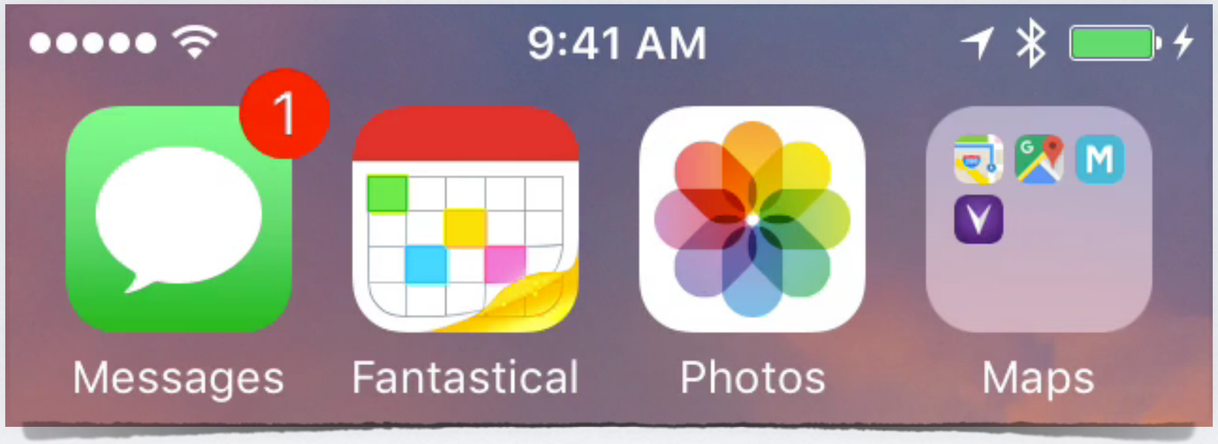
SOFTENING ROUTINES



SOFTENING ROUTINES



SOFTENING ROUTINES



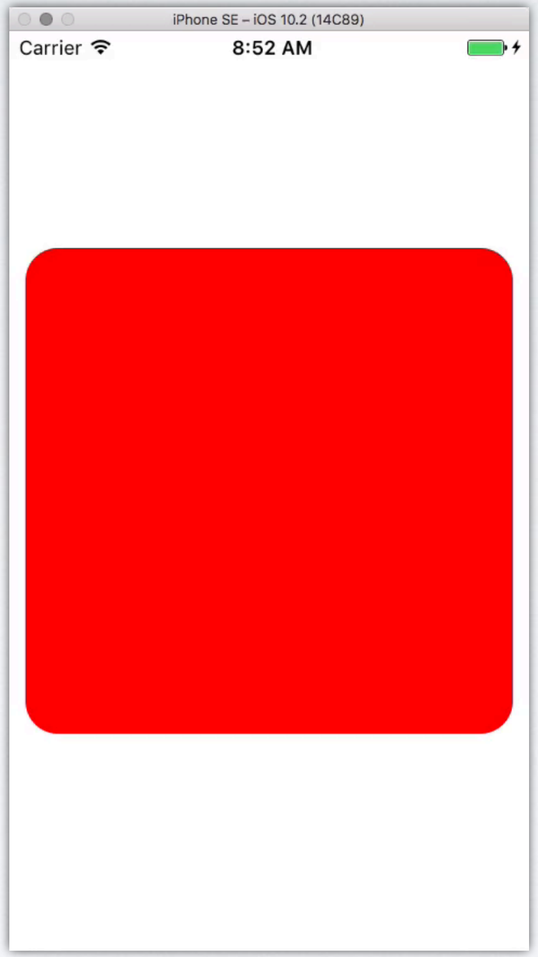
CORE ANIMATION

- Introduced in OS X 10.5 (“Leopard”, 2007) via (then-secret) iPhone team
- Implicit animation model
  - Don't have to build animation objects
  - Interpolation is handled automatically

LET'S SEE HOW IT WORKS

- Visual building block (the view) exists on screen
- A view can contain anything
- Views are backed by **layers**, which are their bitmap representations—a sort of snapshot of their contents
- Core Animation animates layer property changes by default

FADE DEMO



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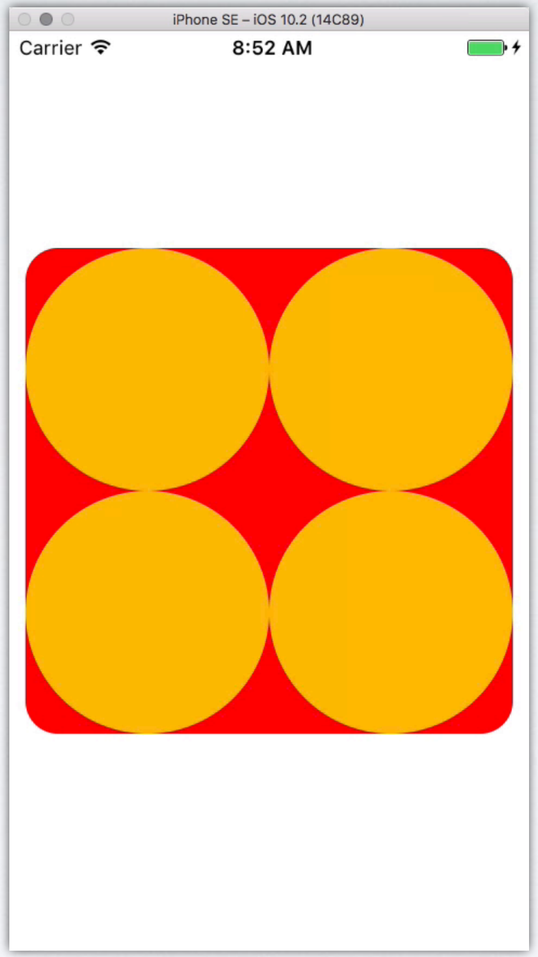

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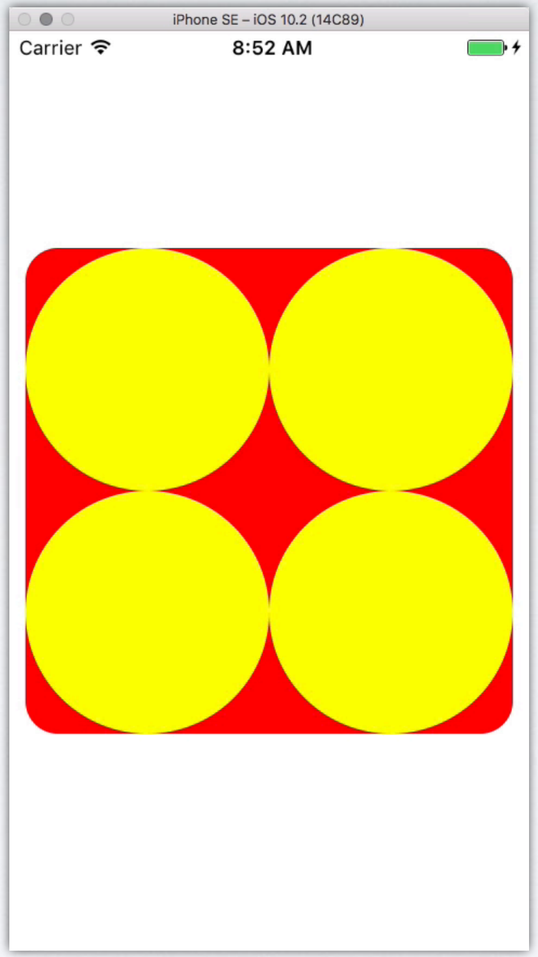


THE CODE

```
let sublayer = CALayer()
sublayer.frame = CGRect(x: x, y: y, width: size, height: size)
sublayer.backgroundColor = UIColor.yellow.cgColor
sublayer.cornerRadius = size / 2
sublayer.opacity = 0
view.layer.addSublayer(sublayer)
```

```
layer.opacity = (layer.opacity == 1 ? 0 : 1)
```

THAT'S IT?

LESSON #1: DISCOVERABILITY

ENHANCING DISCOVERABILITY

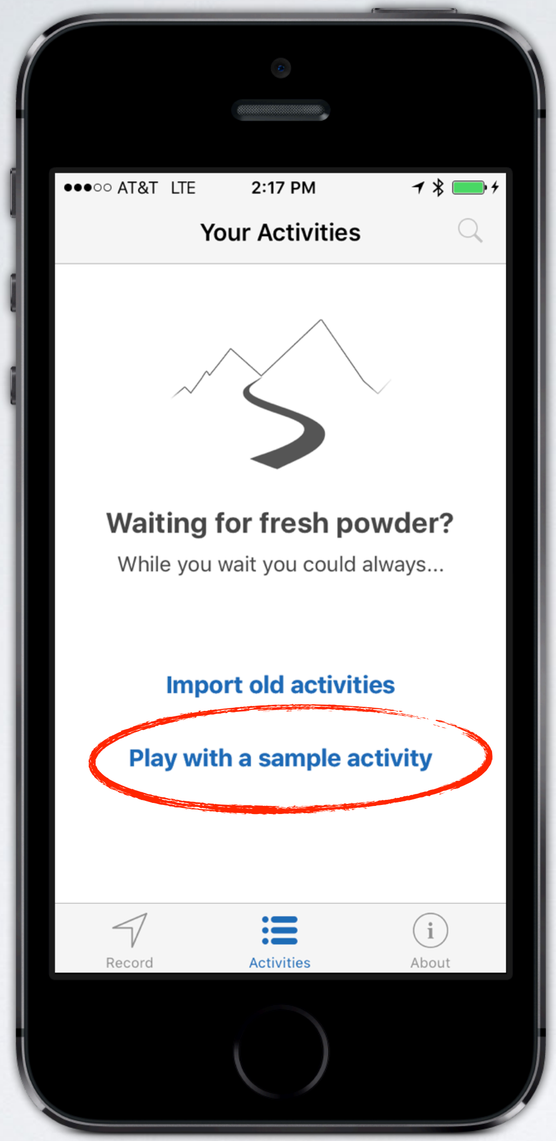
- Piggyback on things you are doing in nearby APIs (here, layer property changes)
- Consider opting in to a behavior by default

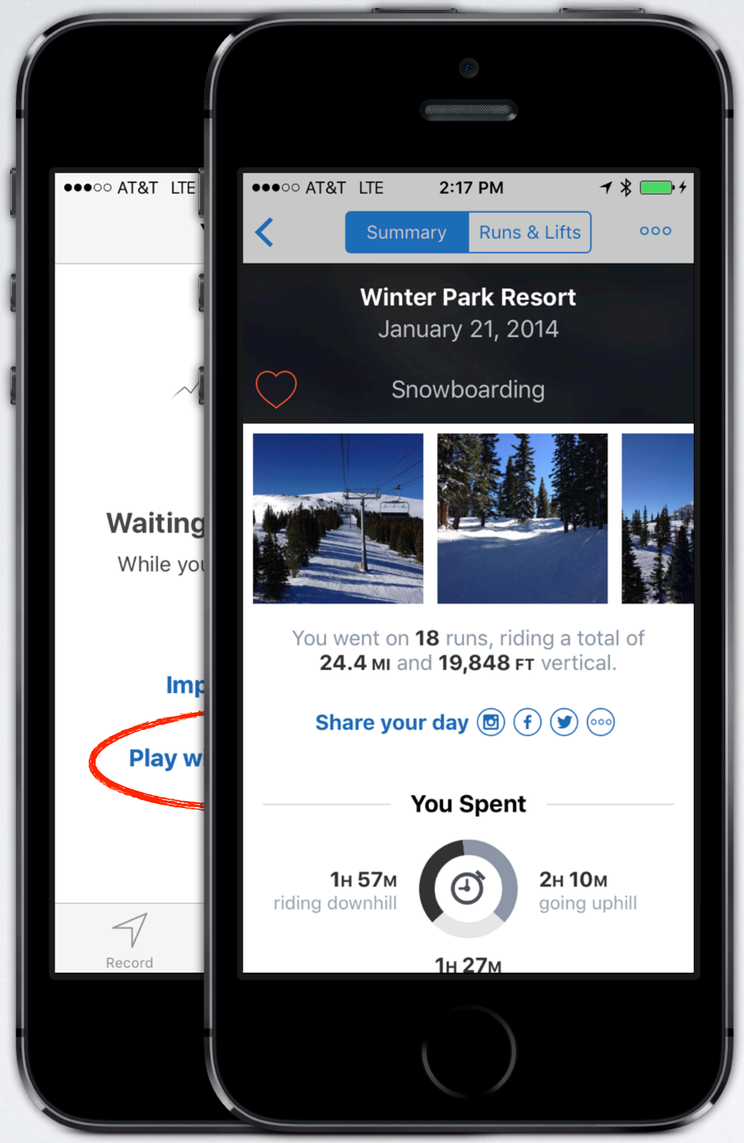
ENHANCING DISCOVERABILITY

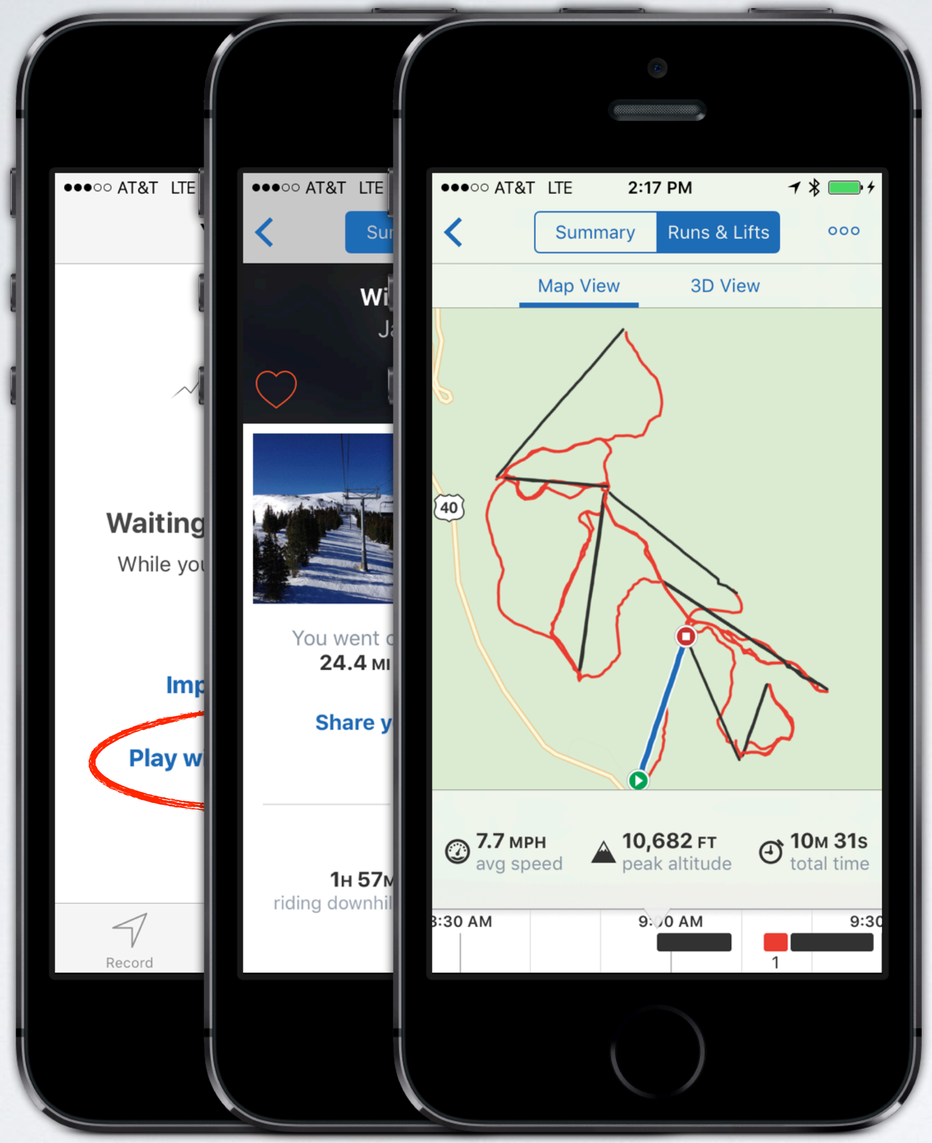
- Build SDKs?
  - Database initial data
  - View default background color
  - First run demo
- Build apps?
  - Default populated data
  - Partially-hidden content to encourage gestures

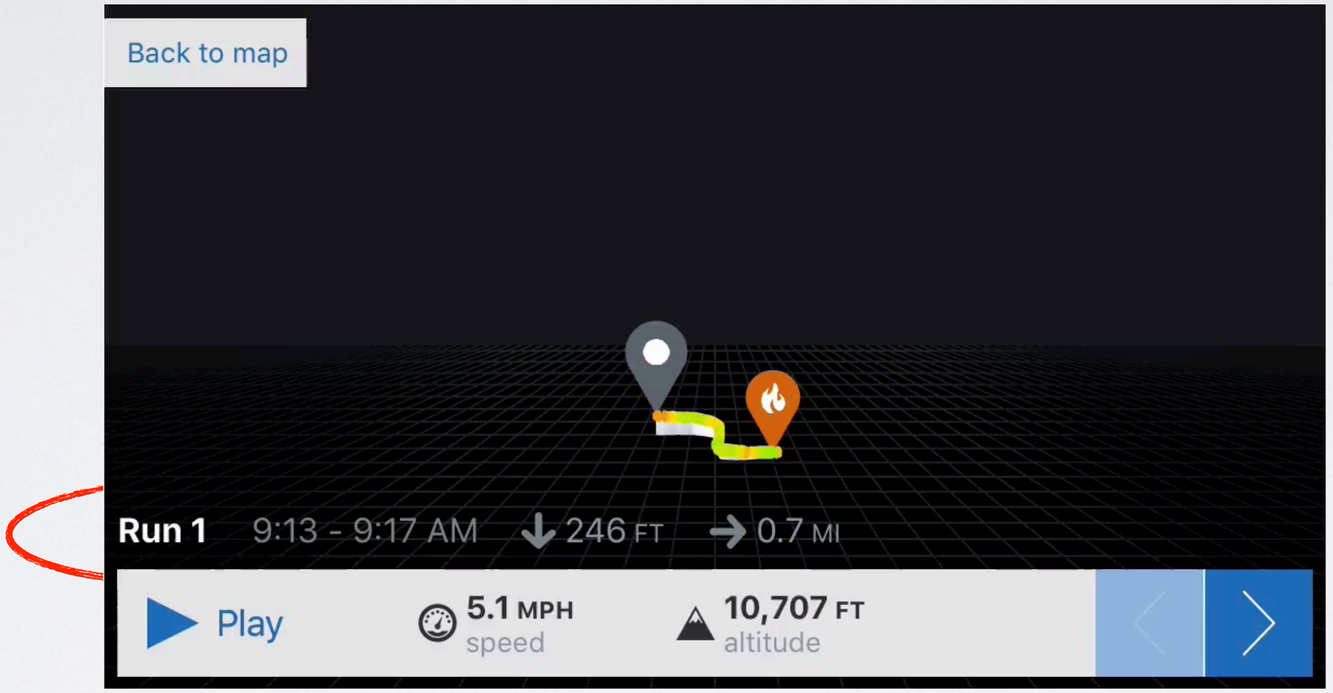
SLOPES

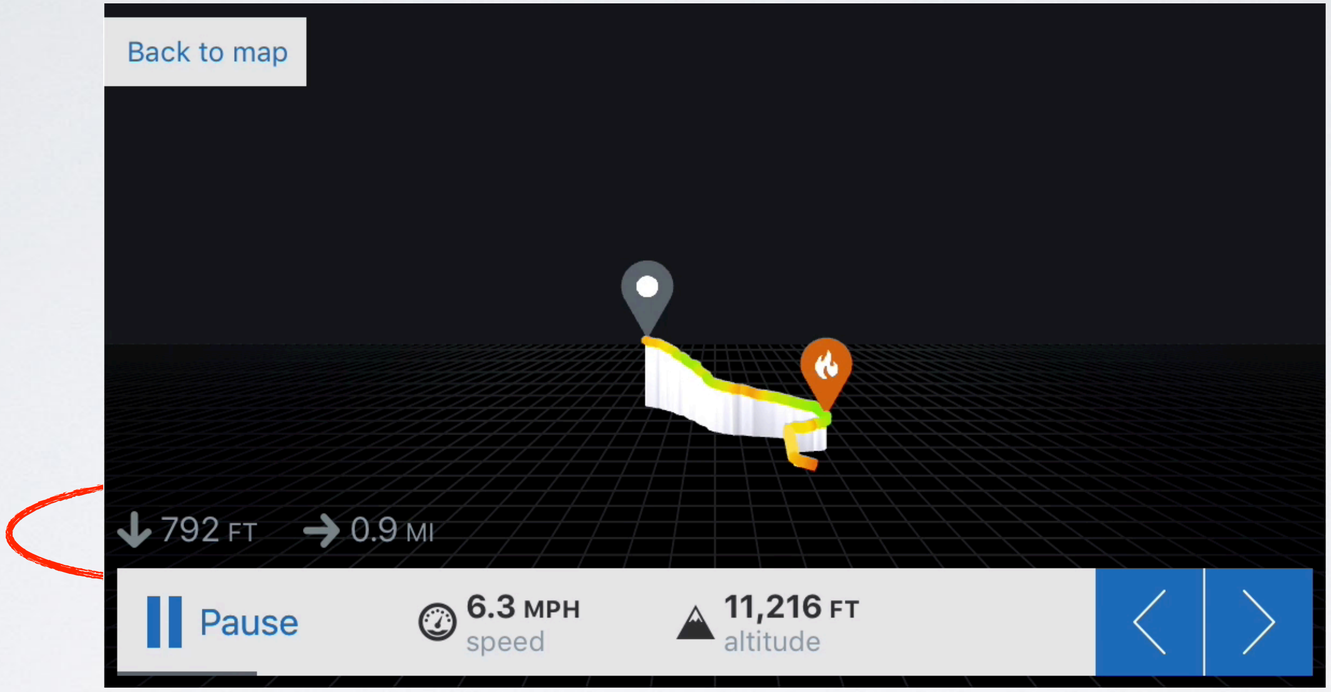
getslopes.com


●●●○○ AT&T LTE
2:17 PM
Your Activities
Waiting for fresh powder?
While you wait you could always...
Import old activities
Play with a sample activity
Record
Activities
About


●●●○○ AT&T LTE
Waiting
While yo
Imp
Play w
Record
●●●○○ AT&T LTE 2:17 PM
Summary
Runs & Lifts
Winter Park Resort
January 21, 2014
Snowboarding
You went on 18 runs, riding a total of
24.4 MI and 19,848 FT vertical.
Share your day
You Spent
1H 57M
riding downhill
2H 10M
going uphill
1H 27M


●●●○○ AT&T LTE
Waiting
Record
●●●○○ AT&T LTE
24.4 MI
1H 57M
riding downhil
●●●○○ AT&T LTE 2:17 PM
Summary
Runs & Lifts
Map View
3D View
40
7.7 MPH
avg speed
10,682 FT
peak altitude
10M 31S
total time
8:30 AM
9:30 AM
9:30
1


Back to map
Run 1
9:13 - 9:17 AM
246 FT
0.7 MI
Play
5.1 MPH
speed
10,707 FT
altitude


Back to map
792 FT
0.9 MI
Pause
6.3 MPH
speed
11,216 FT
altitude

THERE IS A **LOT** MORE!

- Explicit animations
- Complex animation building blocks
- Keyframe animations
- Custom properties
- Per-property runtime checks for actions
- Replicated layers
- Nested transactions
- Transitions between views and layers

LESSON #2: FLEXIBILITY

FLEXIBILITY

- Allows for uses beyond the primary use case
- But doesn't bog down the primary use case

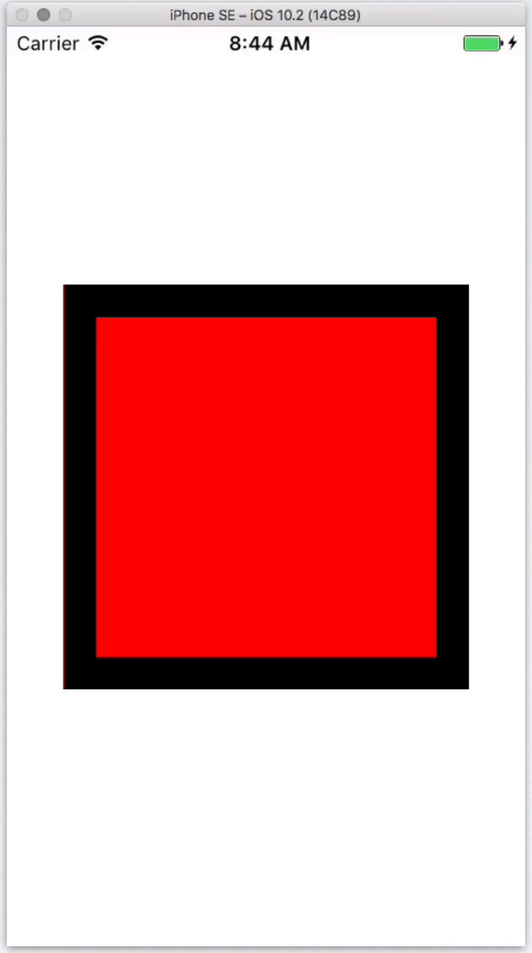
EXPLICIT ANIMATIONS

- Instead of just setting property values, you construct animation objects
- Able to customize parameters on individual animations

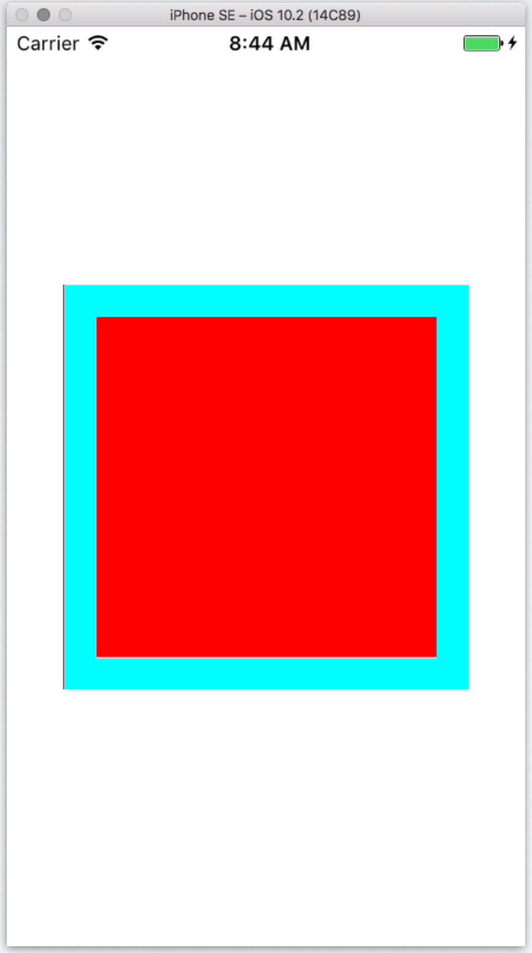
EXPLICIT ANIMATIONS

```
let animation = CABasicAnimation(keyPath: "borderColor")
animation.duration = 2
animation.timingFunction = CAMediaTimingFunction(
    name: kCAMediaTimingFunctionLinear
)
animation.fromValue = layer.borderColor
animation.toValue = UIColor.cyan.cgColor
animation.isRemovedOnCompletion = false
animation.fillMode = kCAFillModeForwards
layer.add(animation, forKey: "borderColor")
```

EXPLICIT ANIMATIONS



EXPLICIT ANIMATIONS



TRANSACTIONS

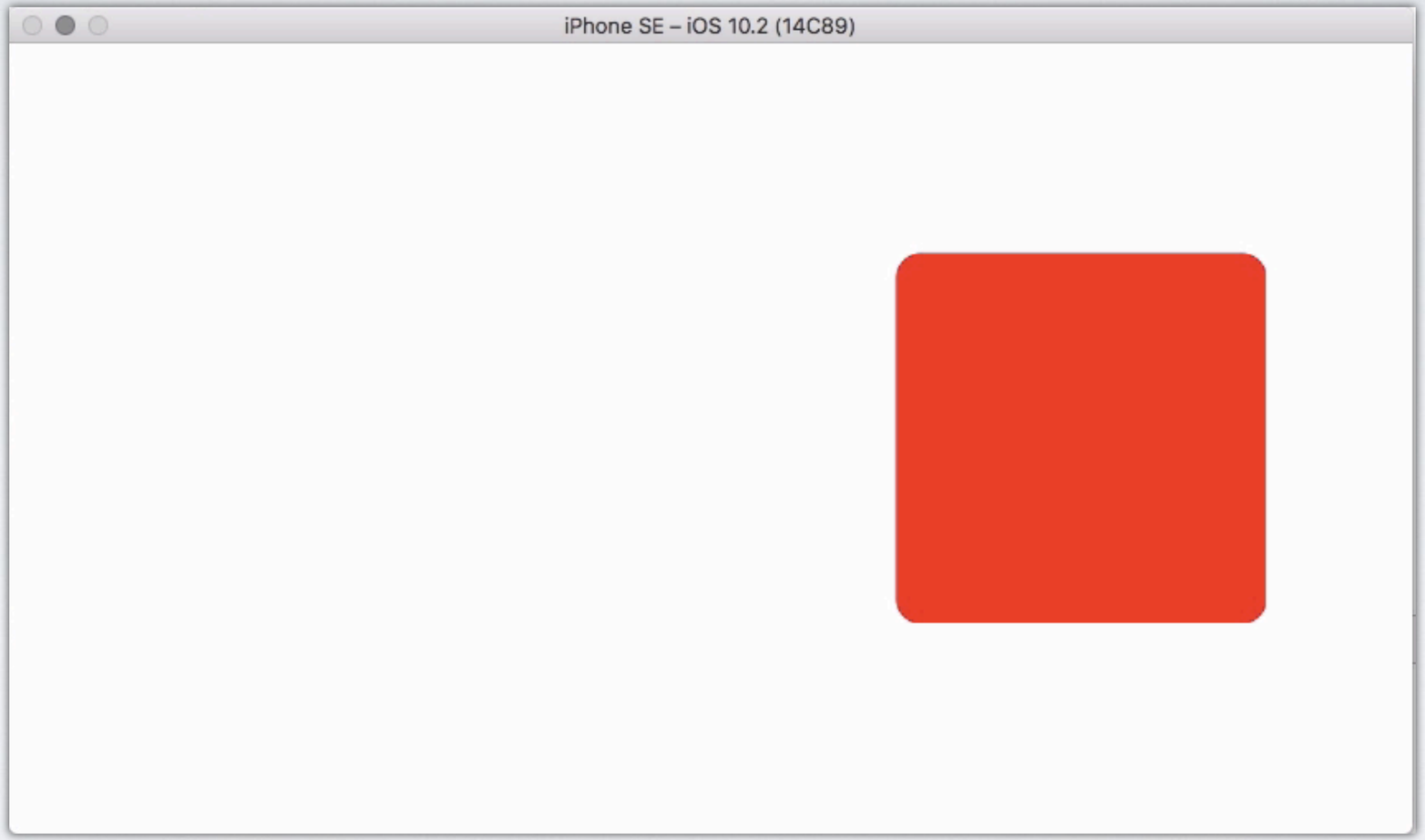
- Allow you to specify custom animation parameters
- Allow you to precisely control time, acceleration, and completion actions across multiple animations

TRANSACTION EXAMPLE

```
CATransaction.begin()
CATransaction.setAnimationDuration(0.1)
CATransaction.setAnimationTimingFunction(CAMediaTimingFunction(name:
    kCAMediaTimingFunctionEaseInEaseOut))

layer.position = CGPoint(x: layer.position.x + 150, y: layer.position.y)
layer.transform = CATransform3DMakeScale(0.5, 0.5, 1)

CATransaction.commit()
```

TRANSACTION EXAMPLE

TRANSACTION EXAMPLE

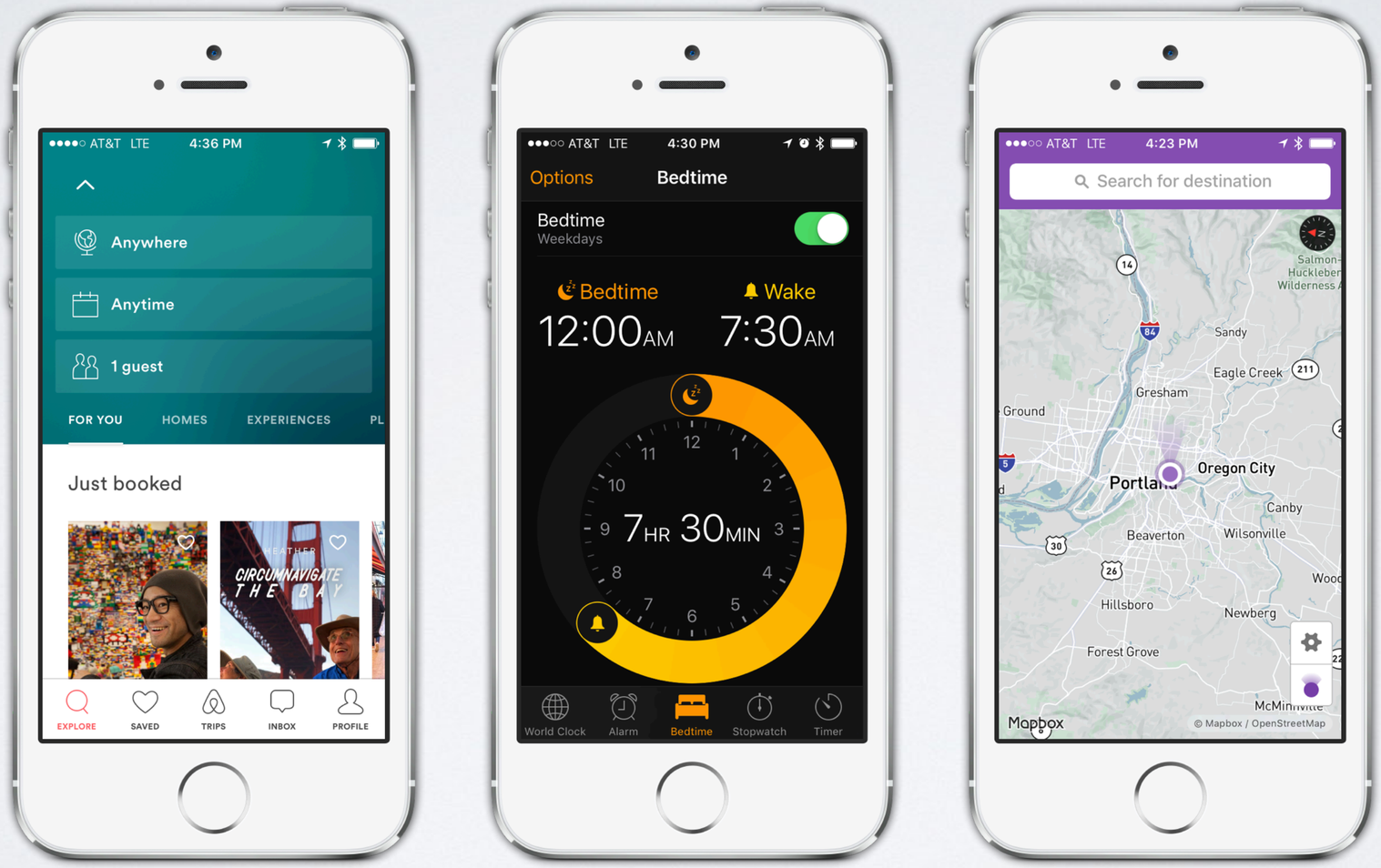


LESSON #3: MAKE IT INTUITIVE

TRANSACTION EXAMPLE REVISITED

```
CATransaction.begin()
CATransaction.setAnimationDuration(0.1)
CATransaction.setAnimationTimingFunction(CAMediaTimingFunction(name:
    kCAMediaTimingFunctionEaseInEaseOut))

layer.position = CGPoint(x: layer.position.x + 150, y: layer.position.y)
layer.transform = CATransform3DMakeScale(0.5, 0.5, 1)

CATransaction.commit()
```

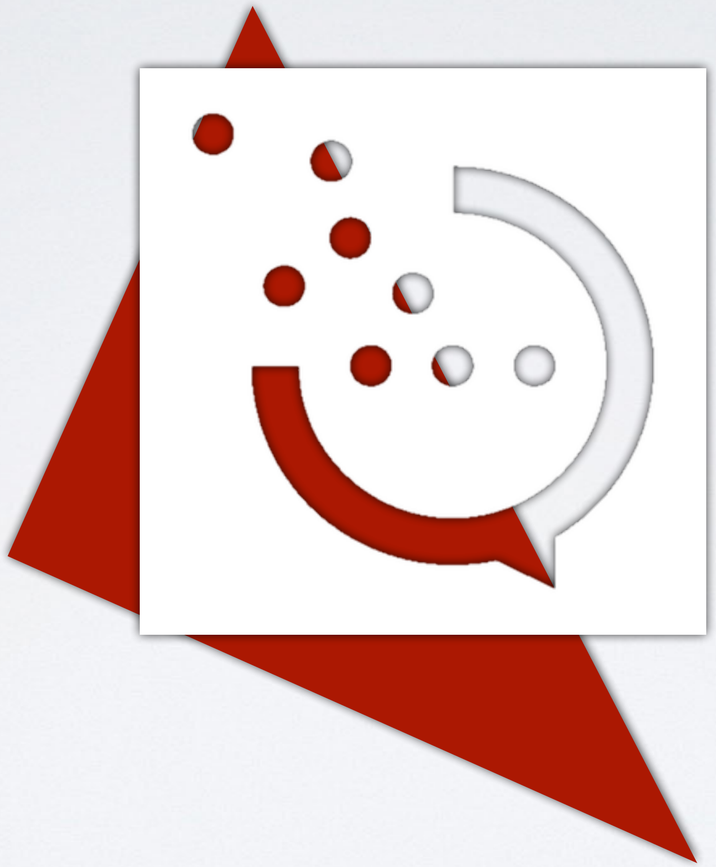
GRADIENTS


AT&T LTE 4:36 PM
Anywhere
Anytime
1 guest
FOR YOU
HOMES
EXPERIENCES
Just booked
EXPLORE
SAVED
TRIPS
INBOX
PROFILE
AT&T LTE 4:30 PM
Options
Bedtime
Bedtime
Weekdays
Bedtime
12:00AM
Wake
7:30AM
7HR 30MIN
World Clock
Alarm
Bedtime
Stopwatch
Timer
AT&T LTE 4:23 PM
Search for destination
Sandy
Eagle Creek
Gresham
Oregon City
Canby
Beaverton
Wilsonville
Hillsboro
Newberg
Forest Grove
Mapbox
© Mapbox / OpenStreetMap

GRADIENTS

```
let layer = CAGradientLayer()
layer.colors = [UIColor.red.cgColor, UIColor.purple.cgColor]
```

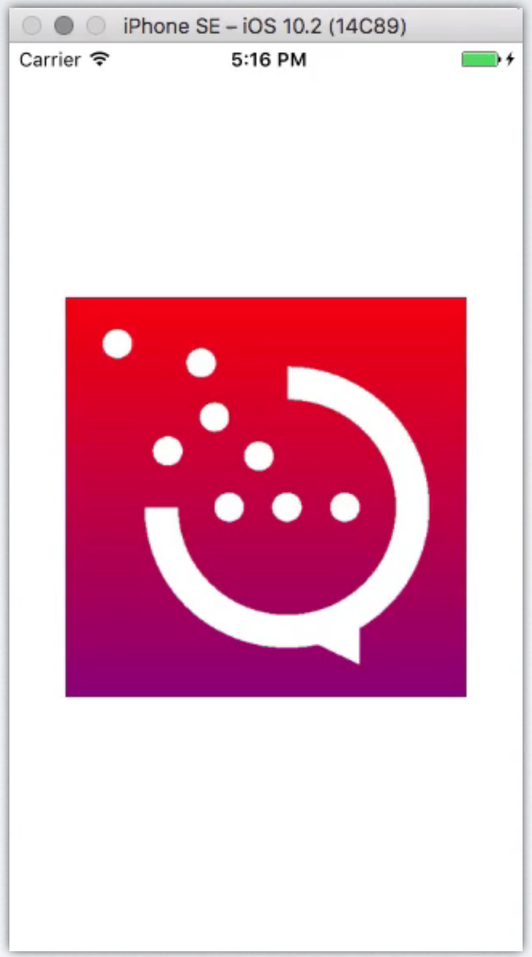
MASKS



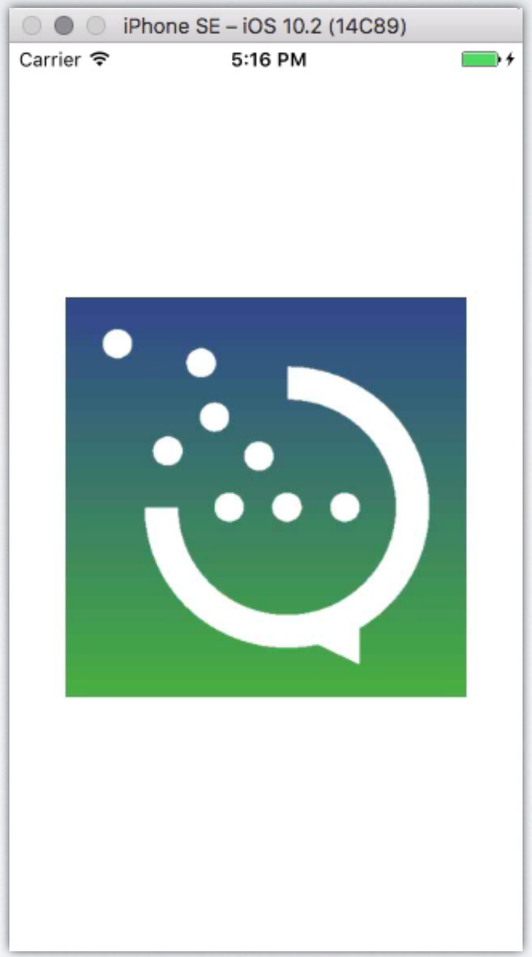
MASKS

```
let logo = CALayer()
logo.contents = UIImage(named: "itt.png")!.cgImage
layer.mask = logo
```

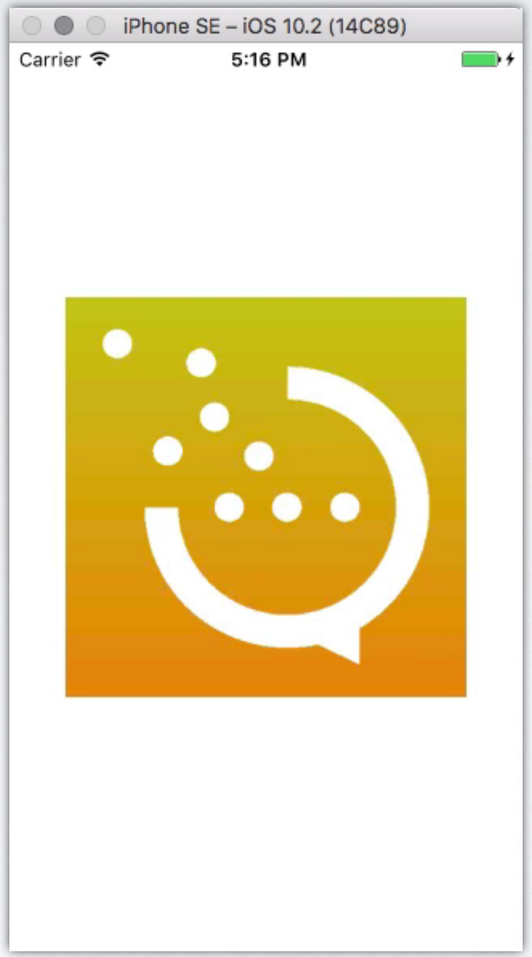
GRADIENT & MASK COMBINED



GRADIENT & MASK COMBINED



GRADIENT & MASK COMBINED

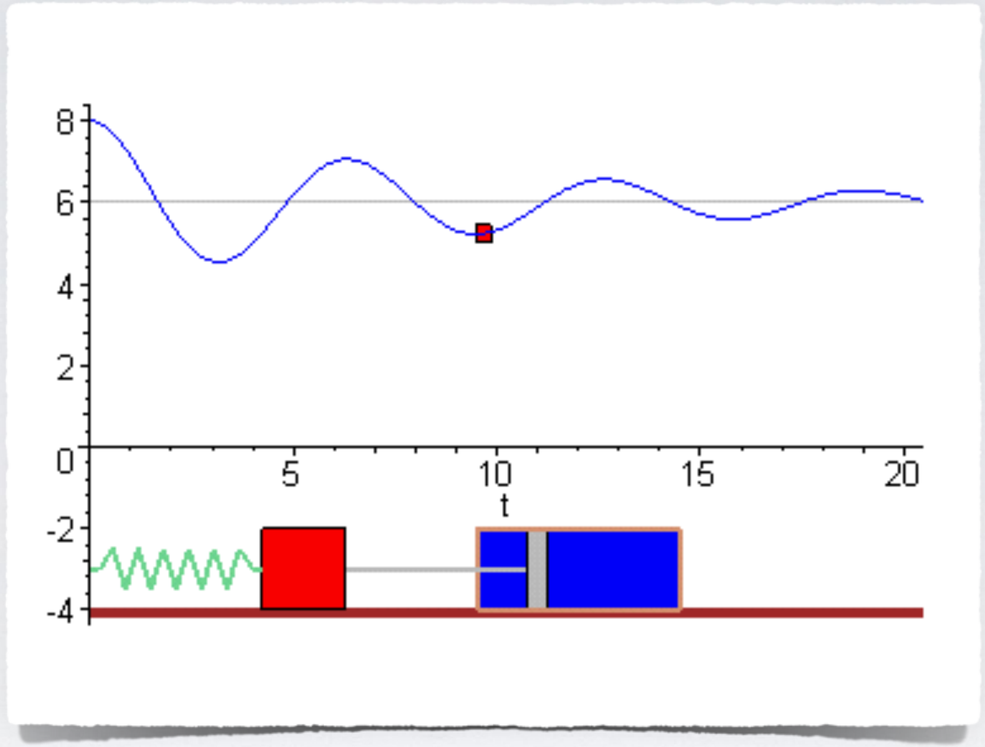


LESSON #4: HIDE COMPLEXITY

HIDE COMPLEXITY

- We use **`.mask`** to set a mask
- We use **`.colors`** to set gradient colors
- Complexity of drawing and animating is hidden

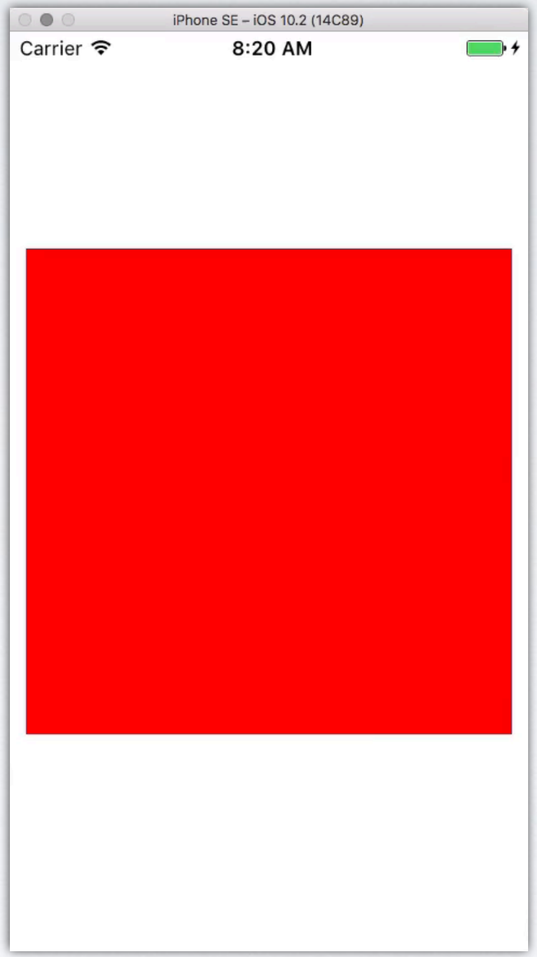
SPRING ANIMATIONS



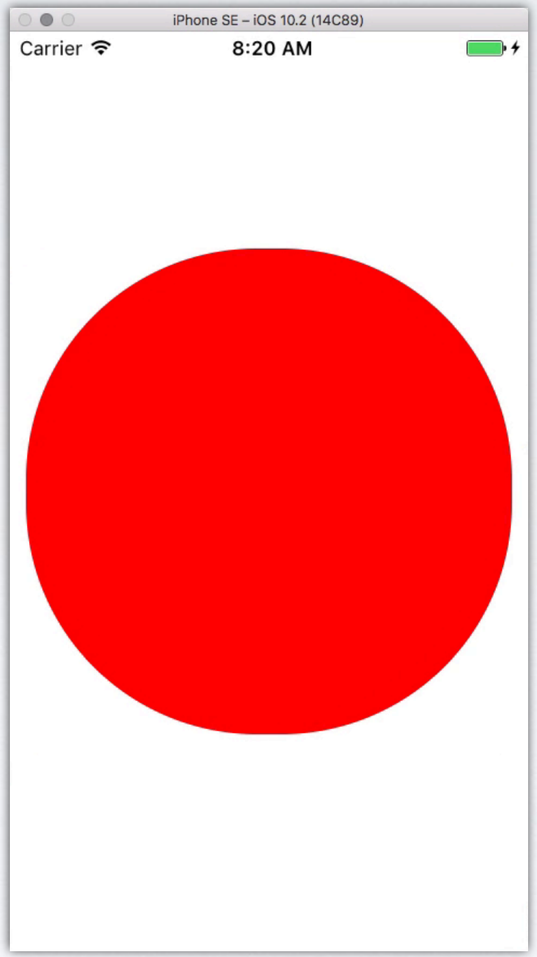
AS YOU MIGHT EXPECT…

- This is trivial in Core Animation
- Accomplished with **`CASpringAnimation`**
- Useful for more organic-feeling interfaces

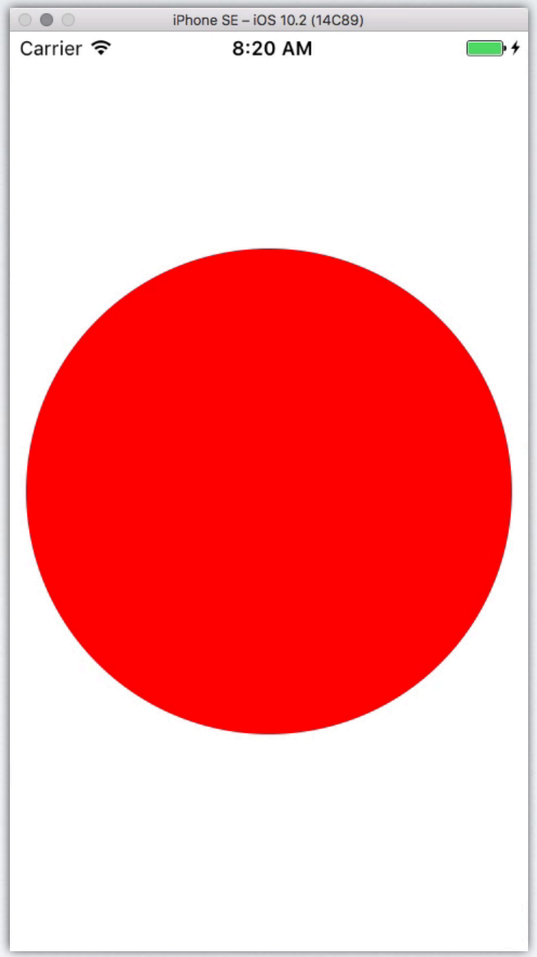
SPRING ANIMATIONS



SPRING ANIMATIONS



SPRING ANIMATIONS



SPRING ANIMATIONS

```
let spring = CASpringAnimation()
spring.damping = 5
spring.duration = 5
spring.fromValue = layer.cornerRadius
spring.toValue = layer.bounds.size.width / 2
spring.fillMode = kCAFillModeForwards
spring.isRemovedOnCompletion = false
layer.add(spring, forKey: "cornerRadius")
```

LESSON #5: MAKE IT FUN

FUN

- Core Animation has a playfulness to it
- This reflects the potential for playful interactions in your apps
- Admittedly, you don't have to dress up animations very much—it’s not an API like string encoding or task queuing

LESSON #6: MAKE IT UNSURPRISING

MAKE APIS UNSURPRISING

- Consider if the default implicit animation duration was *zero seconds*
- You wouldn't be able to see animations, even though they were the *default behavior!*

“If a necessary feature has a high astonishment factor, it may be necessary to redesign the feature.”

–Principle of Least Astonishment (PoLA)

SURPRISING APIS

- Classic example: a list or array **`add()`** or **`insert()`** that sorts
- Consider what is least surprising to the user, rather than the expected behavior given knowledge of the inner workings

LESSON #7: EXTENSIBILITY

EXTENSIBLE

- Core Animation supports custom properties
- Not just the predefined ones like **`opacity`** & **`position`**

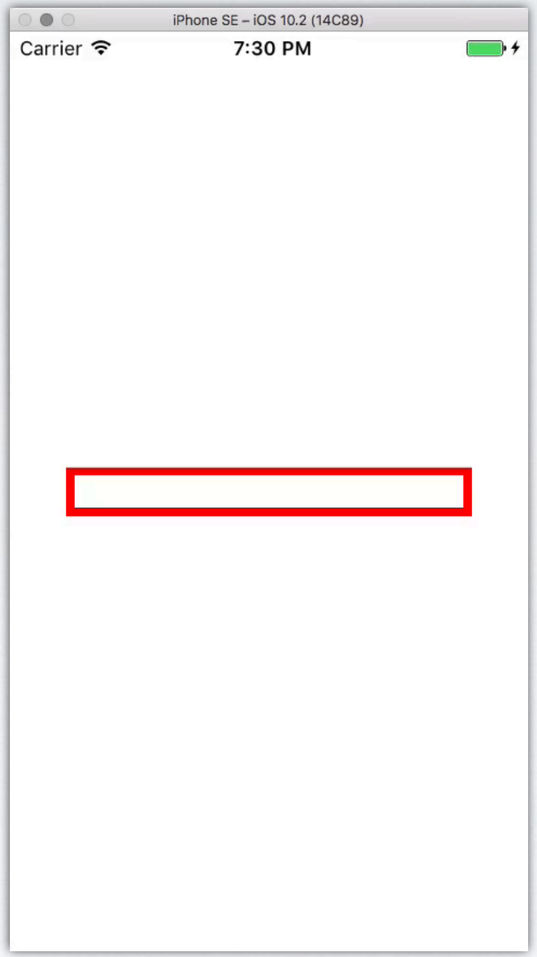
EXTENSIBLE

```
class ProgressLayer: CALayer {

    @NSManaged var progress: CGFloat

    override class func needsDisplay(forKey key: String) -> Bool {
        if key == "progress" {
            return true
        }
        return super.needsDisplay(forKey: key)
    }

    override func draw(in ctx: CGContext) {
        ctx.setFillColor(UIColor.red.cgColor)
        ctx.addRect(
            CGRect(
                x: 0,
                y: 0,
                width: presentation()!.progress * bounds.size.width,
                height: bounds.size.height
            )
        )
        ctx.fillPath()
    }

}
```

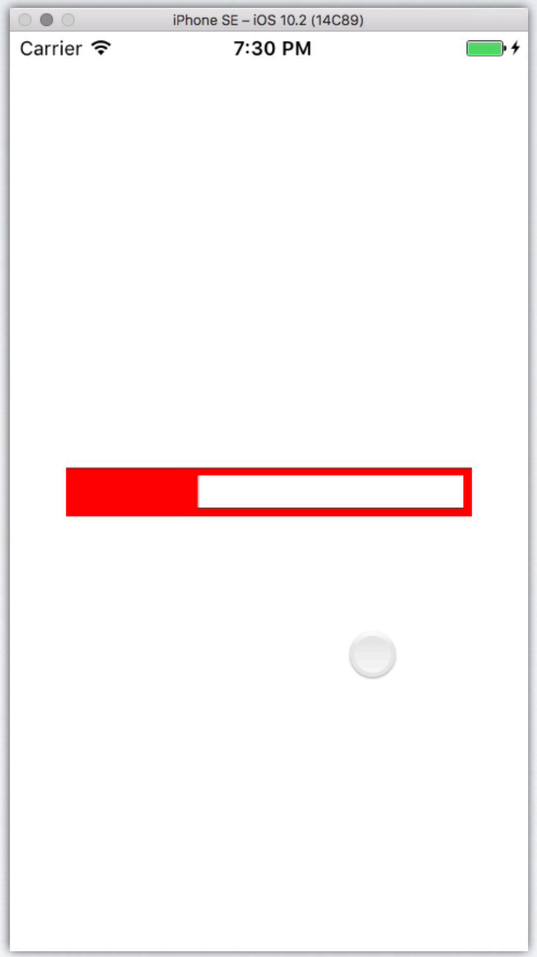
EXTENSIBLE

```
let progress = touch.location(in: view).x / view.bounds.size.width
let animation = CABasicAnimation(keyPath: "progress")
animation.timingFunction = CAMediaTimingFunction(
    name: kCAMediaTimingFunctionEaseInEaseOut
)
animation.fromValue = layer.presentation()!.progress
animation.toValue = progress
animation.isRemovedOnCompletion = false
animation.fillMode = kCAFillModeForwards
animation.duration = 1
layer.add(animation, forKey: "progress")
```

EXTENSIBLE



EXTENSIBLE



LESSON #8: DOCUMENT IT

DOCUMENTATION

- Not the most glamorous thing, but very important
- This is important even for your future self
- But especially important for other consumers

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About Core Animation

Core Animation is a graphics rendering and animation infrastructure available on both iOS and OS X that you use to animate the views and other visual elements of your app. With Core Animation, most of the work required to draw each frame of an animation is done for you. All you have to do is configure a few animation parameters (such as the start and end points) and tell Core Animation to start. Core Animation does the rest, handing most of the actual drawing work off to the onboard graphics hardware to accelerate the rendering. This automatic graphics acceleration results in high frame rates and smooth animations without burdening the CPU and slowing down your app.

If you are writing iOS apps, you are using Core Animation whether you know it or not. And if you are writing OS X apps, you can take advantage of Core Animation with extremely little effort. Core Animation sits beneath AppKit and UIKit and is integrated tightly into the view workflows of Cocoa and Cocoa Touch. Of course, Core Animation also has interfaces that extend the capabilities exposed by your app's views and give you more fine-grained control over your app's animations.

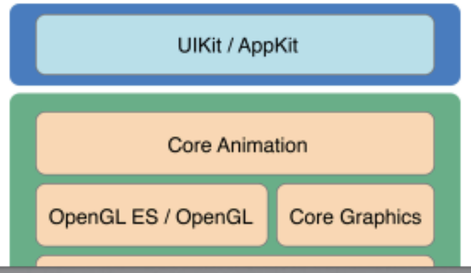

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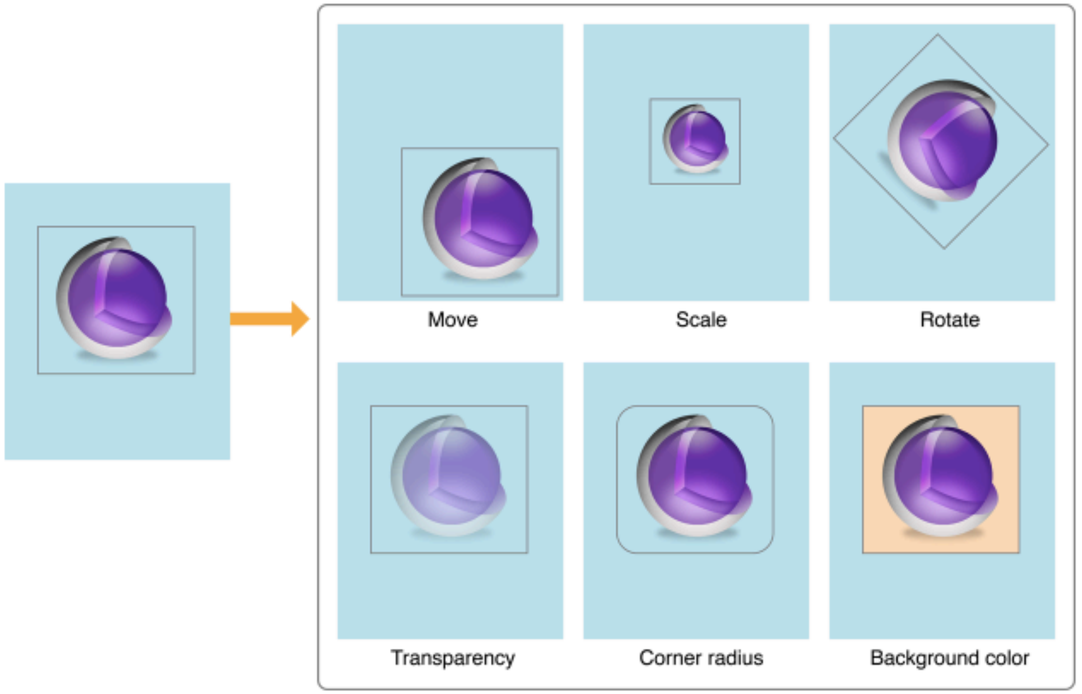
Figure 1-2 Examples of animations you can perform on layers



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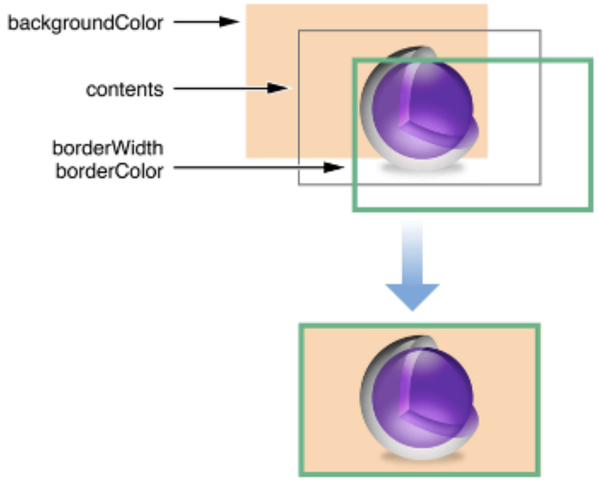
background color is rendered behind the layer's contents image and the border is rendered on top of that image, as shown in Figure 2-3. If the layer contains sublayers, they also appear underneath the border. Because the background color sits behind your image, that color shines through any transparent portions of your image.

Figure 2-3 Adding a border and background to a layer



Listing 2-5 shows the code needed to set the background color and border for a layer. All of these properties are animatable.

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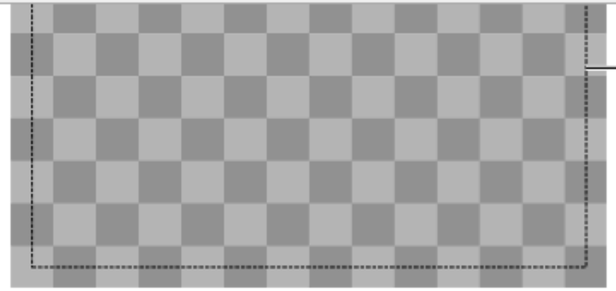
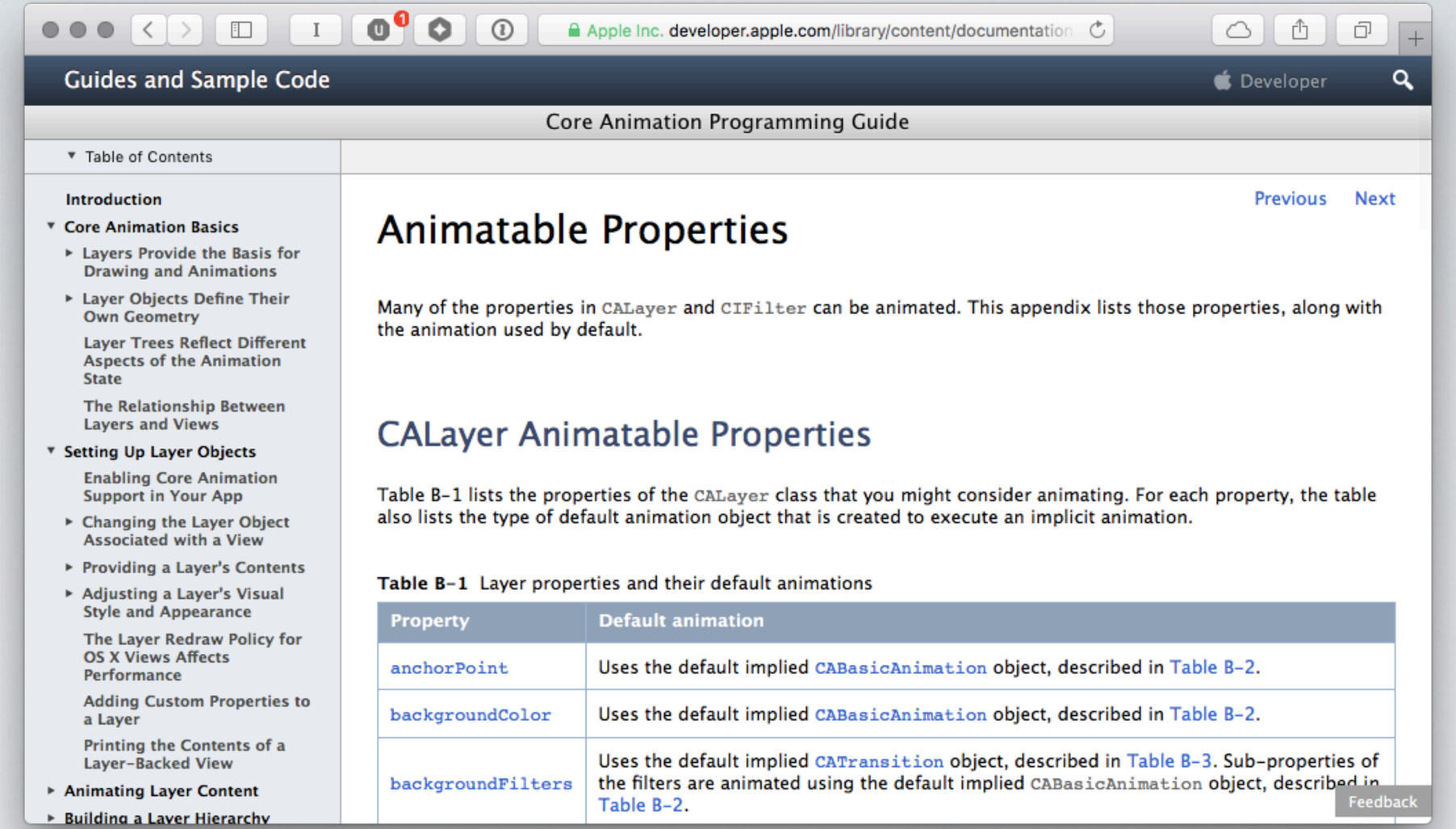


The following `CALayer` properties specify a layer's geometry:

- `bounds`
- `position`
- `frame` (computed from the `bounds` and `position` and is not animatable)
- `anchorPoint`
- `cornerRadius`
- `transform`
- `zPosition`

iOS Note: The `cornerRadius` property is supported only in iOS 3.0 and later.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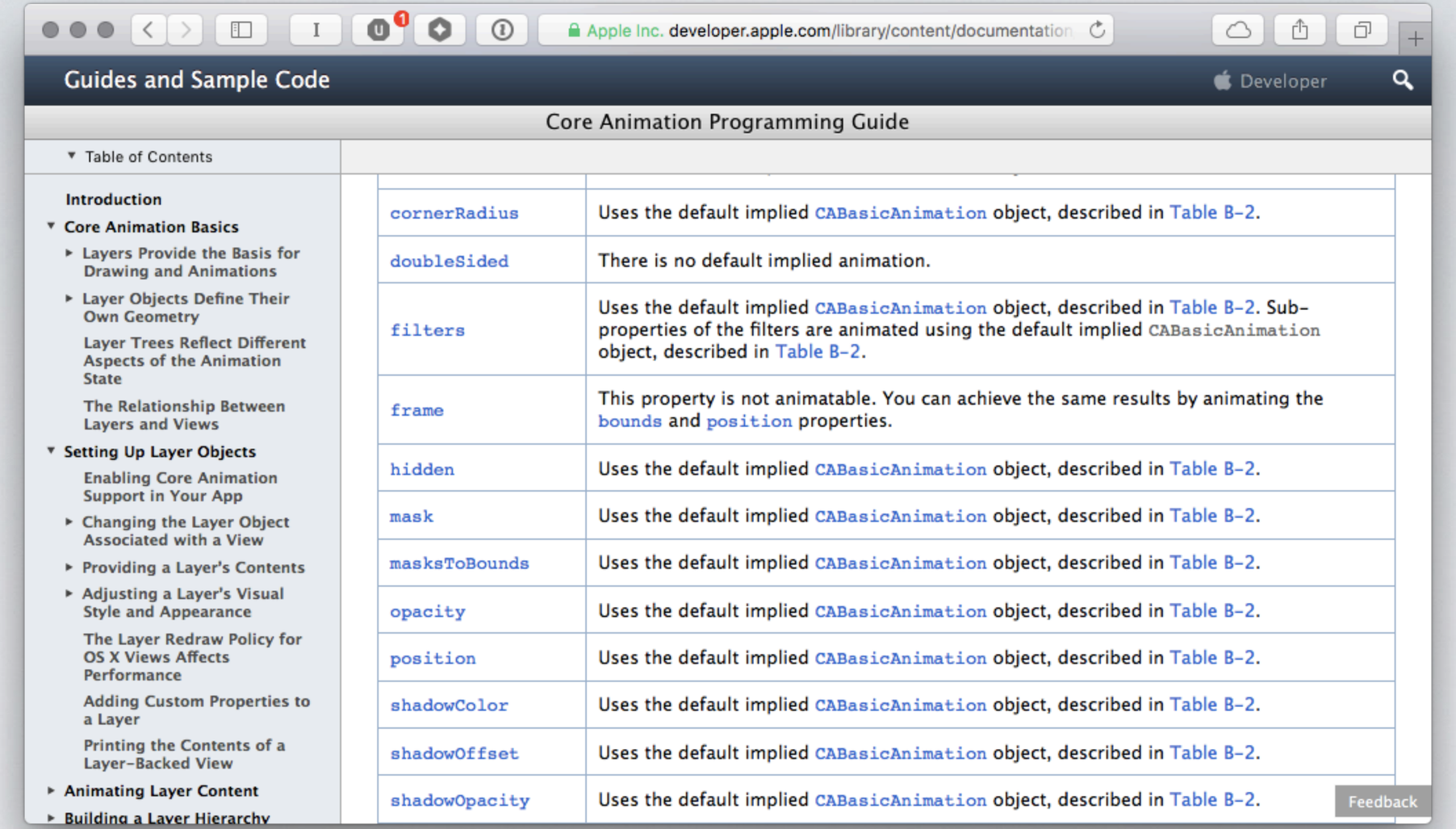
Animatable Properties
Many of the properties in CALayer and CIFilter can be animated. This appendix lists those properties, along with the animation used by default.
CALayer Animatable Properties
Table B-1 lists the properties of the CALayer class that you might consider animating. For each property, the table also lists the type of default animation object that is created to execute an implicit animation.
Table B-1 Layer properties and their default animations
Property
Default animation
anchorPoint
Uses the default implied CABasicAnimation object, described in Table B-2.
backgroundColor
Uses the default implied CABasicAnimation object, described in Table B-2.
backgroundFilters
Uses the default implied CATransition object, described in Table B-3. Sub-properties of the filters are animated using the default implied CABasicAnimation object, described in Table B-2.
Feedback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cornerRadius
Uses the default implied CABasicAnimation object, described in Table B-2.
doubleSided
There is no default implied animation.
filters
Uses the default implied CABasicAnimation object, described in Table B-2. Sub-properties of the filters are animated using the default implied CABasicAnimation object, described in Table B-2.
frame
This property is not animatable. You can achieve the same results by animating the bounds and position properties.
hidden
Uses the default implied CABasicAnimation object, described in Table B-2.
mask
Uses the default implied CABasicAnimation object, described in Table B-2.
masksToBounds
Uses the default implied CABasicAnimation object, described in Table B-2.
opacity
Uses the default implied CABasicAnimation object, described in Table B-2.
position
Uses the default implied CABasicAnimation object, described in Table B-2.
shadowColor
Uses the default implied CABasicAnimation object, described in Table B-2.
shadowOffset
Uses the default implied CABasicAnimation object, described in Table B-2.
shadowOpacity
Uses the default implied CABasicAnimation object, described in Table B-2.
Feedback

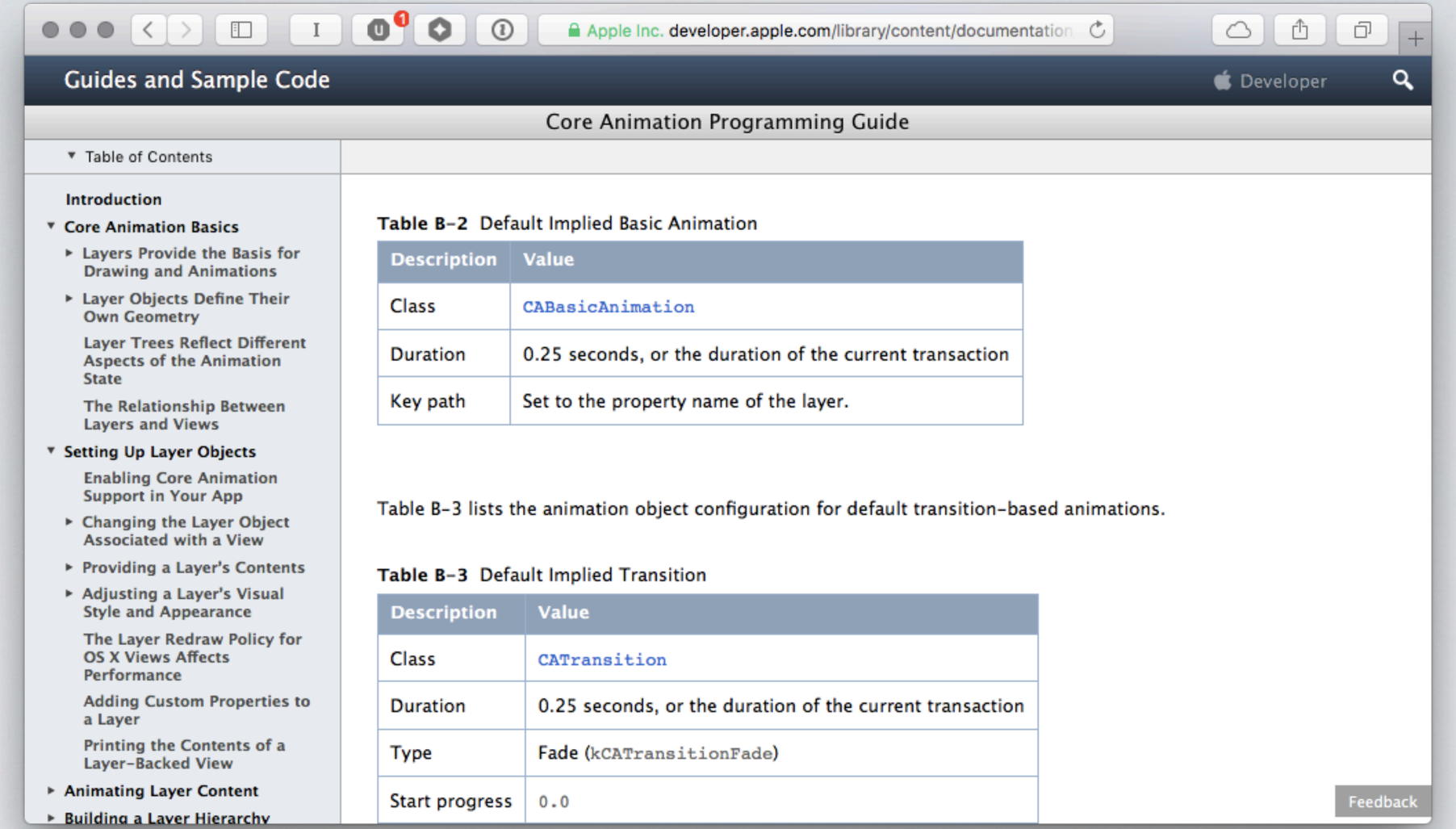
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Table B-2 Default Implied Basic Animation
Description
Value
Class
CABasicAnimation
Duration
0.25 seconds, or the duration of the current transaction
Key path
Set to the property name of the layer.
Table B-3 lists the animation object configuration for default transition-based animations.
Table B-3 Default Implied Transition
Description
Value
Class
CATransition
Duration
0.25 seconds, or the duration of the current transaction
Type
Fade (kCATransitionFade)
Start progress
0.0
Feedback

RECAP

1. Discoverable
2. Flexible
3. Intuitive
4. Hide Complexity
5. Make it fun
6. Keep it unsurprising
7. Allow extensibility
8. Document it

THANK YOU!

Q&A

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