Graphics and Games

#WWDC14

Ingredients of Great Games

Session 602

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Director, Games and Graphics Software

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75 Billion

Downloads

130 Million

Monthly active players

SpriteKit

Metal

SceneKit

Game Center

OpenGL ES 3.0

Game Controllers

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

Apple Design Award 2014
Honoring Outstanding Design and Innovation

Ingredients of Great Games

Allan Schaffer
Graphics and Game Technologies Evangelist

Great Games

Go the extra mile Play tested Immersive Fun core loop

Rewarding Compelling story Engaging Designed for touch

Entertaining Connected

Sticky Localized

Great Games

Innovative Challenging

Optimized Balanced

Rich content Awesome graphics Attention to detail Social

Delighting Polished Competitive Intuitive Beautiful

1

Remove Friction

WELCOME TO
Paddle
Mania
3000

About
Help
Paddle
Mania
3000
Loading...
Top Scores
Themes
Store

Remove Friction

Reduce load time

Get interactive quickly

Only load what's needed now

Move work off main thread

Use Time Profiler to analyze

Remove Friction

Reduce load time

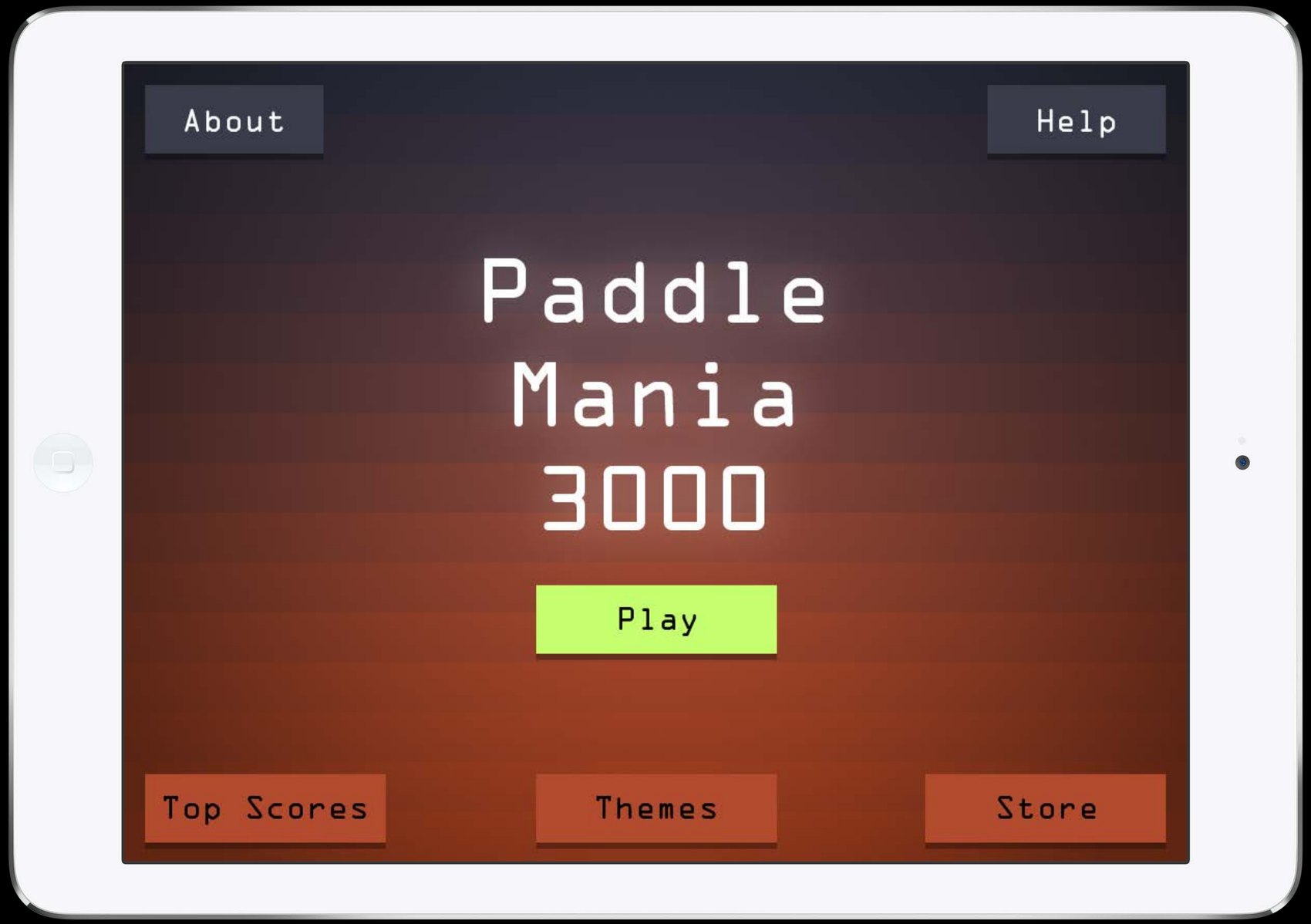
Get interactive quickly

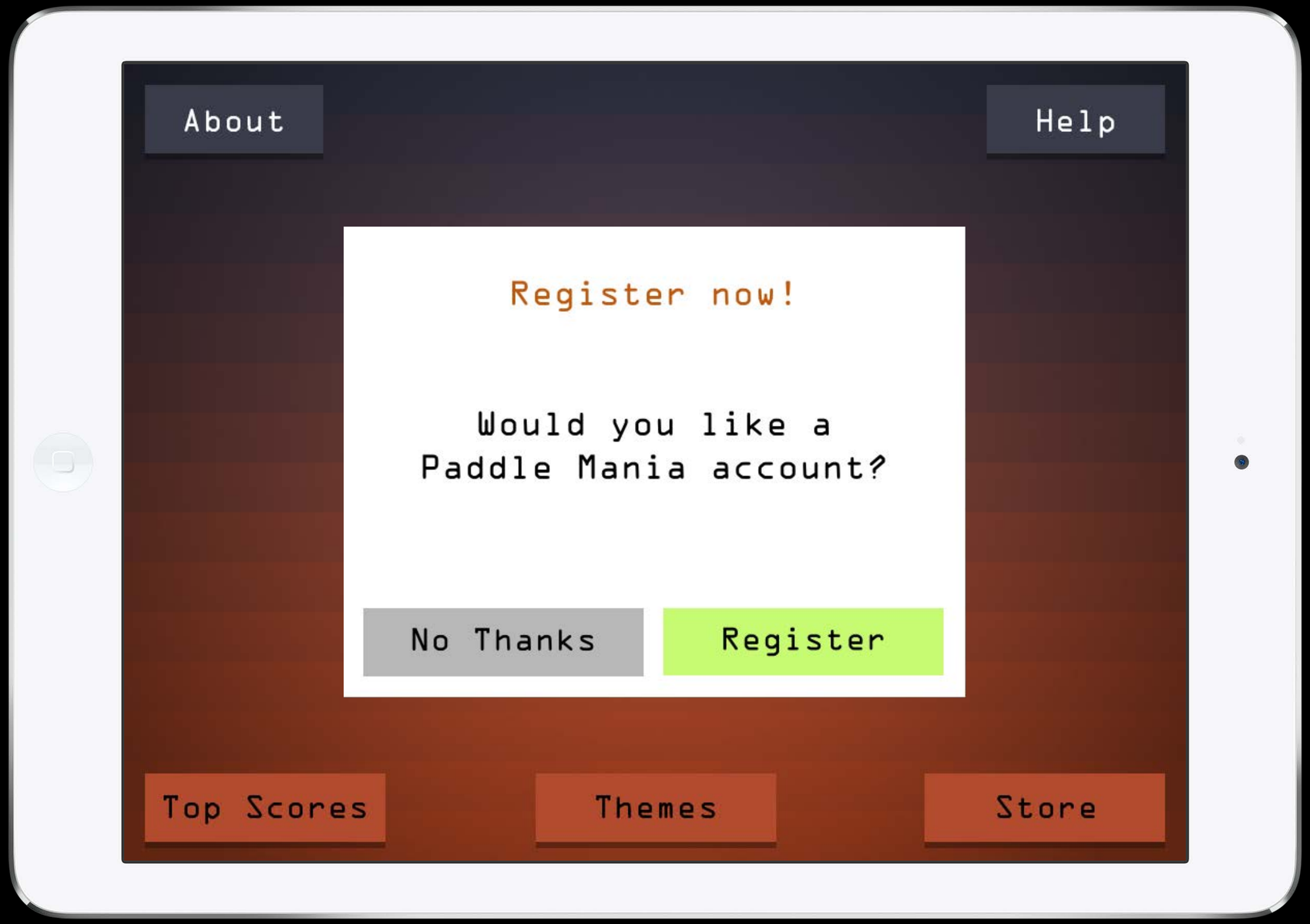
Only load what's needed now

Move work off main thread

Use Time Profiler to analyze

About
Help
Paddle
Mania
3000
Downloading assets...
Top Scores
Themes
Store


About
Help
Paddle
Mania
3000
Play
Top Scores
Themes
Store


About
Help
Register now!
Would you like a
Paddle Mania account?
No Thanks
Register
Top Scores
Themes
Store

Remove Friction

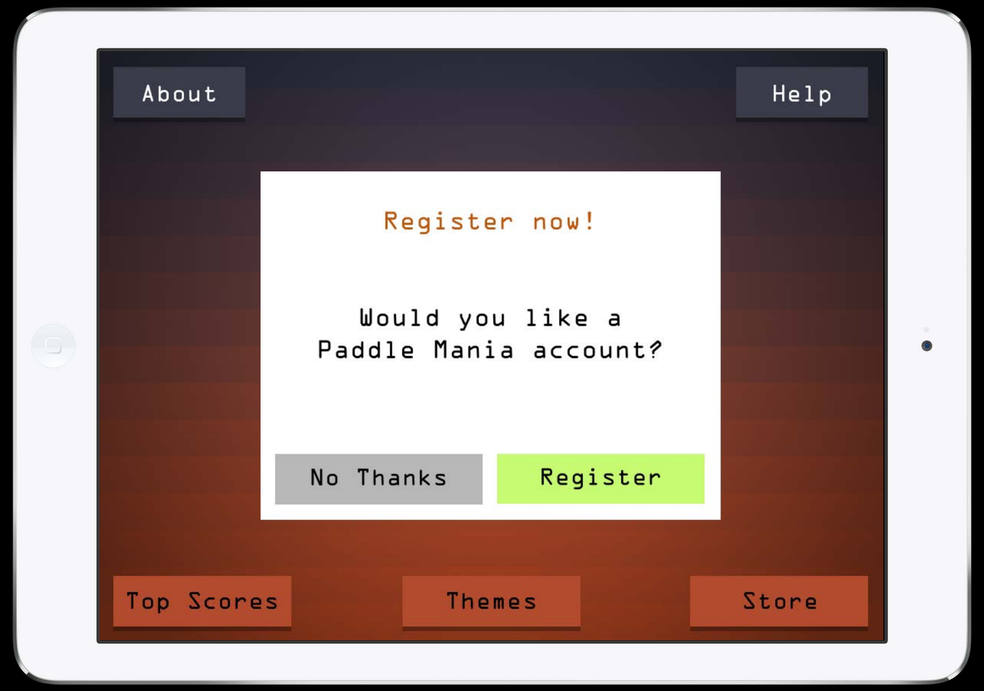
Registration

Provide a bypass

Automate by using Vendor ID

Clearly explain benefits

Defer until needed



Remove Friction

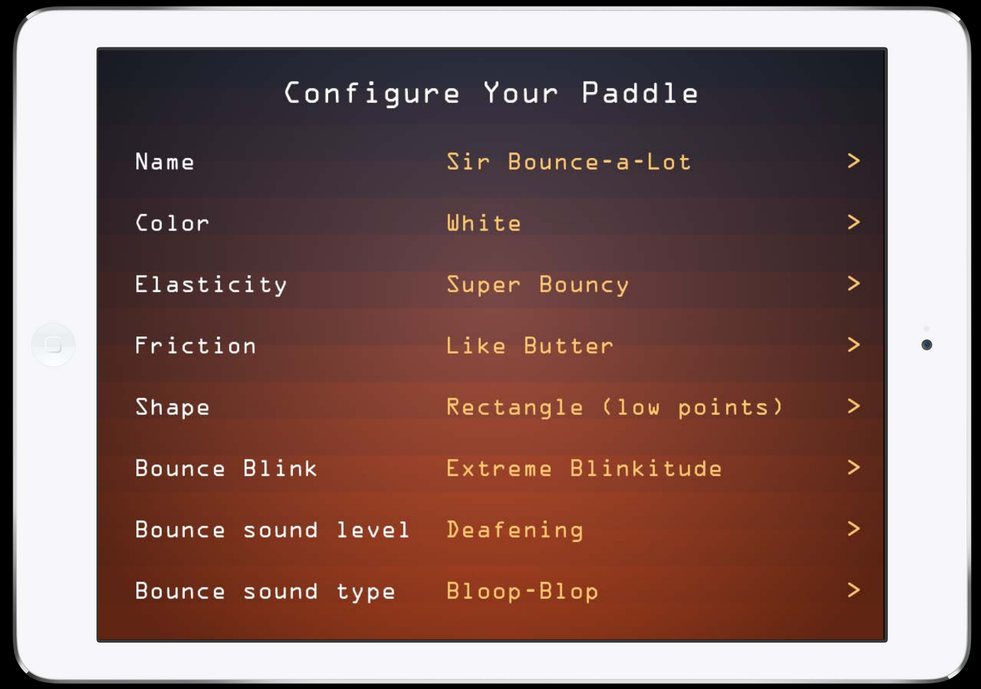
Registration

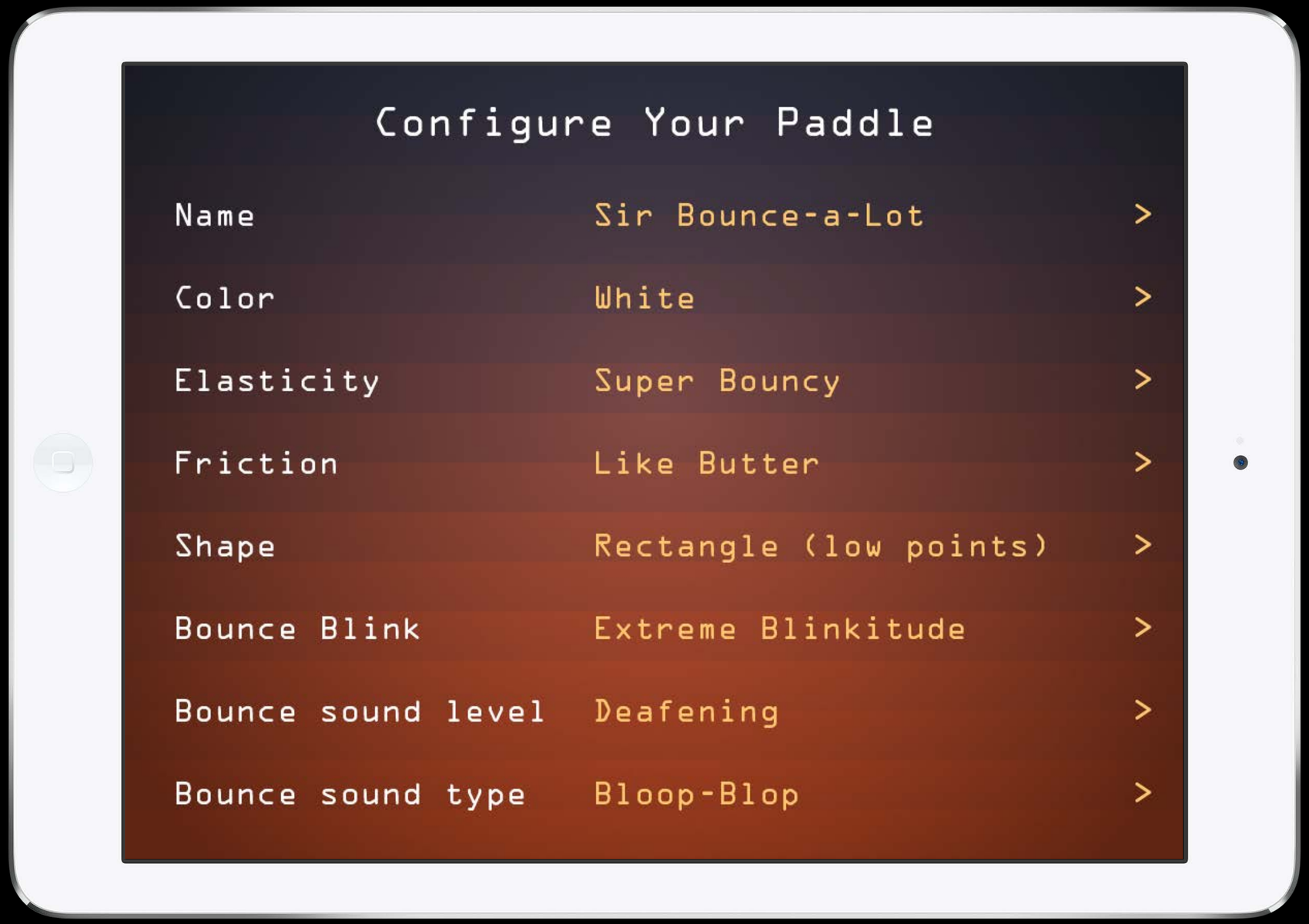
Provide a bypass

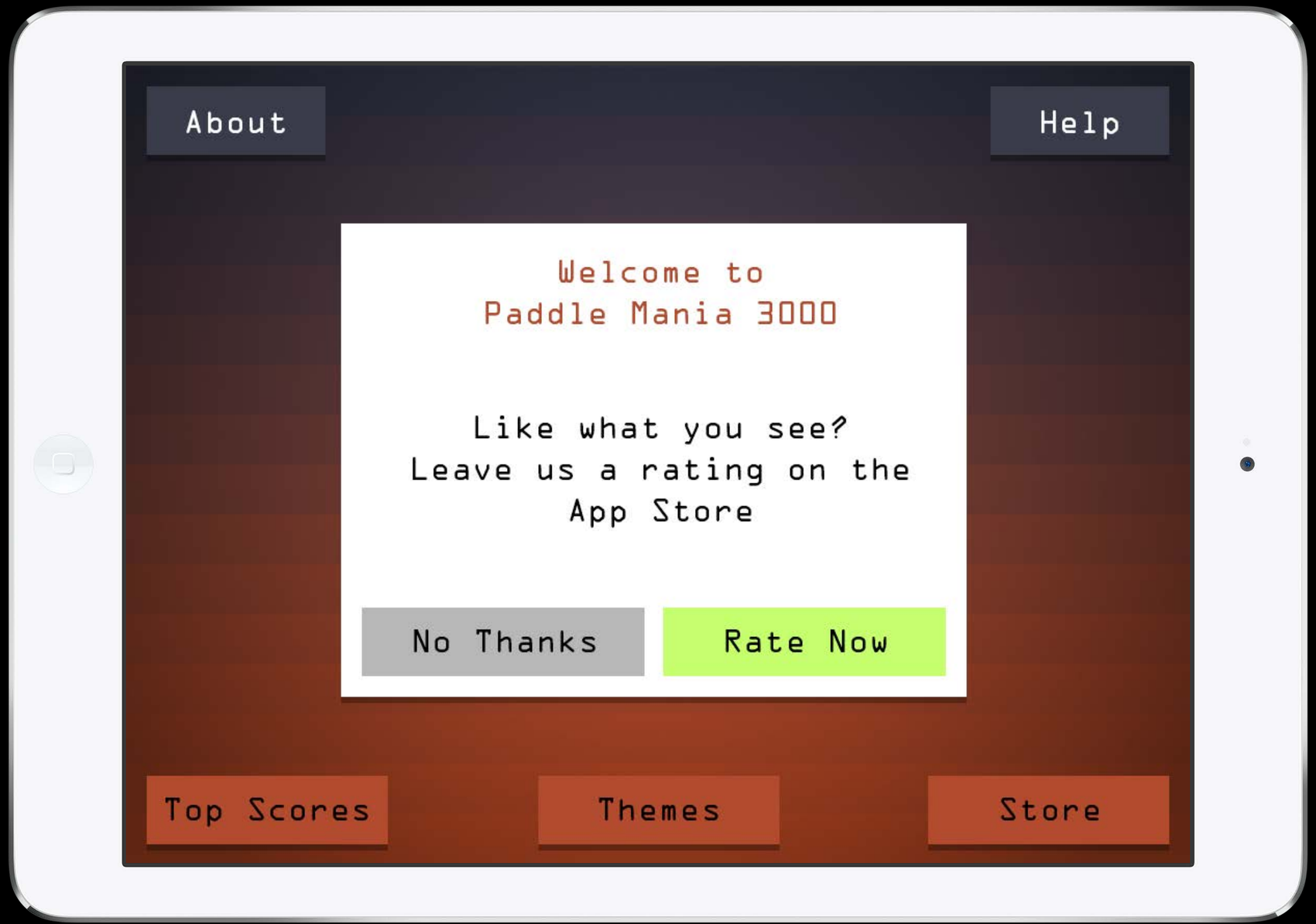
Automate by using Vendor ID

Clearly explain benefits

Defer until needed




Configure Your Paddle
Name
Sir Bounce-a-Lot
>
Color
White
>
Elasticity
Super Bouncy
>
Friction
Like Butter
>
Shape
Rectangle (low points)
>
Bounce Blink
Extreme Blinkitude
>
Bounce sound level
Deafening
>
Bounce sound type
Bloop-Blop
>


About
Help
Welcome to
Paddle Mania 3000
Like what you see?
Leave us a rating on the
App Store
No Thanks
Rate Now
Top Scores
Themes
Store

Remove Friction

Make a great first impression

Reduce load time

Move blocking updates

Streamline registration

Provide escape from intros

Don’t force decisions

Wait to ask for feedback

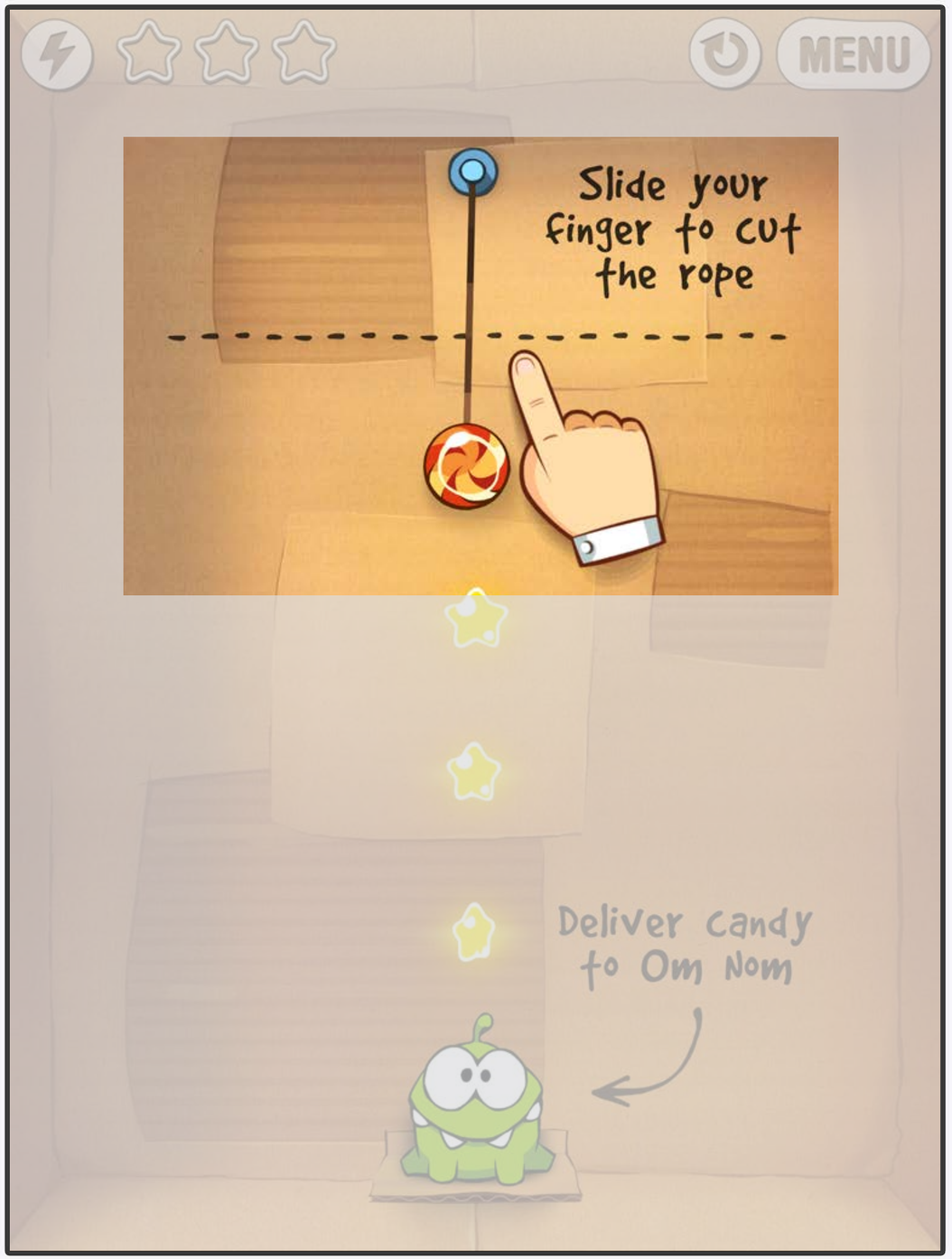
1 Remove Friction

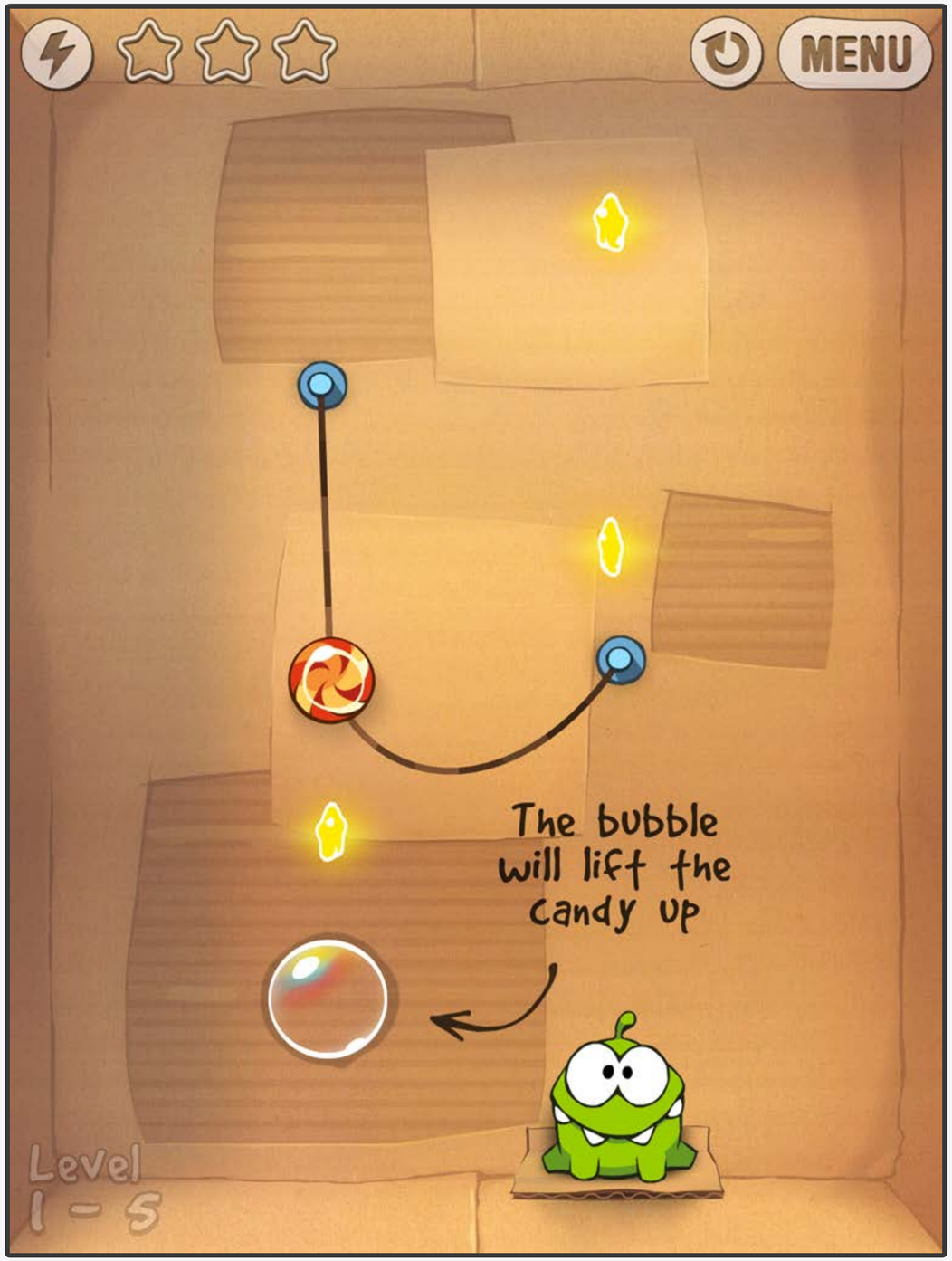
2

Be a Good Teacher

MENU
Slide your finger to cut the rope
Deliver candy to Om Nom

MENU
Slide your finger to cut the rope
Deliver candy to Om Nom


MENU
Slide your finger to cut the rope
Deliver candy to Om Nom


MENU
The bubble will lift the candy up
Level 1 - 5

MENU
Pop the bubble
with your finger

MENU
You can restart the
level by pressing the
button

Be a Good Teacher

Maximize enjoyment

Teach by playing

Show the primary mechanic

Introduce concepts one-at-a-time

Provide tips in context

Give help along the way

Be a Good Teacher

Maximize enjoyment

Teach by playing

Show the primary mechanic

Introduce concepts one-at-a-time

Provide tips in context

Give help along the way

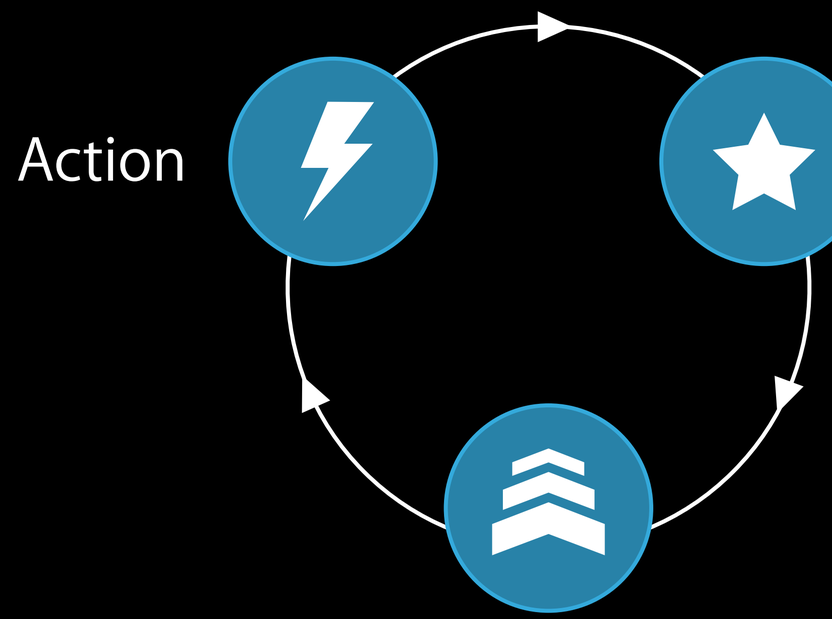
1. Remove Friction
2. Be a Good Teacher

Related Sessions

• Making a Great First Impression with Strong Onboarding Design	Mission	Thursday 2:00PM

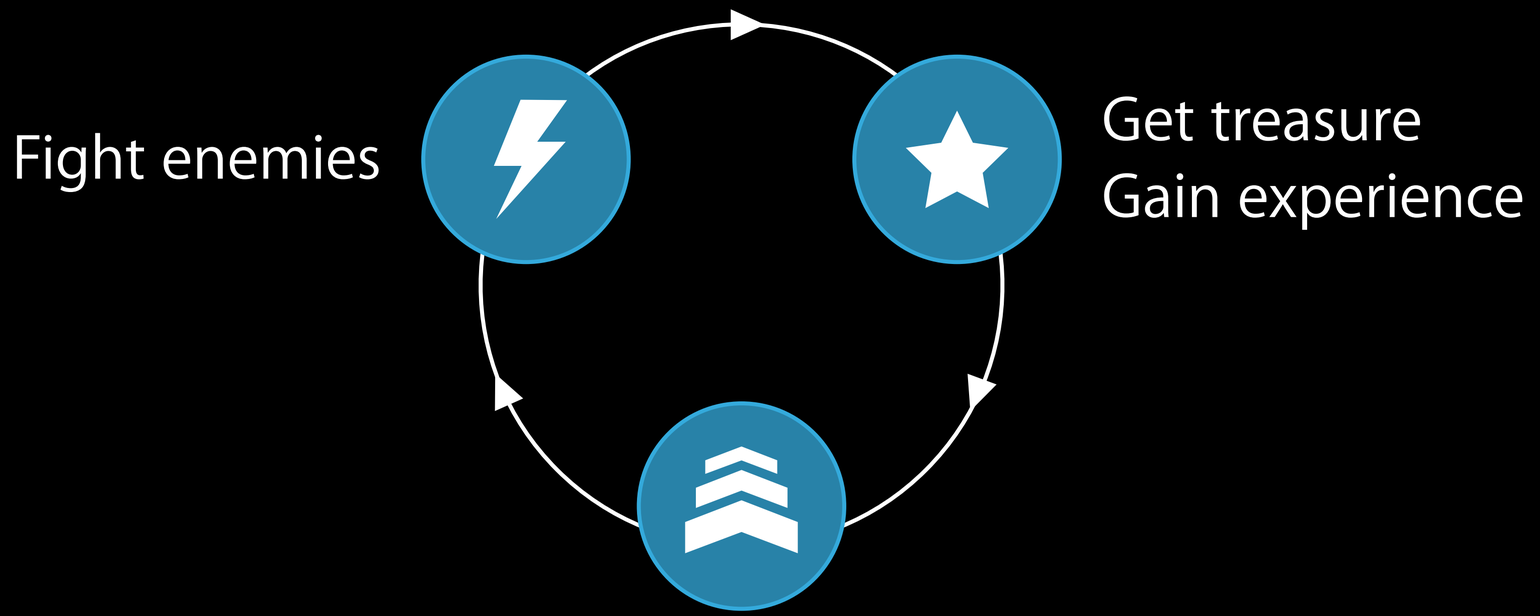
Tune Your Core Loop

Core Loop



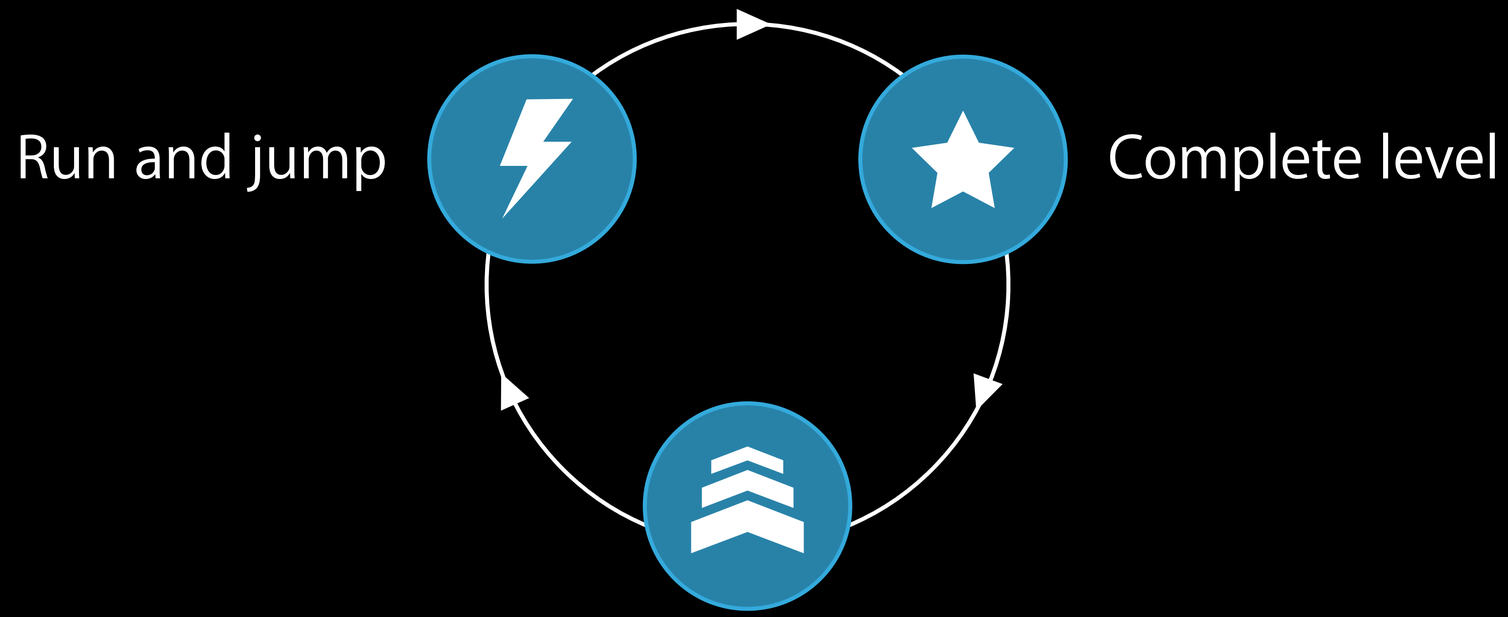
Core Loop

Fantasy/RPG



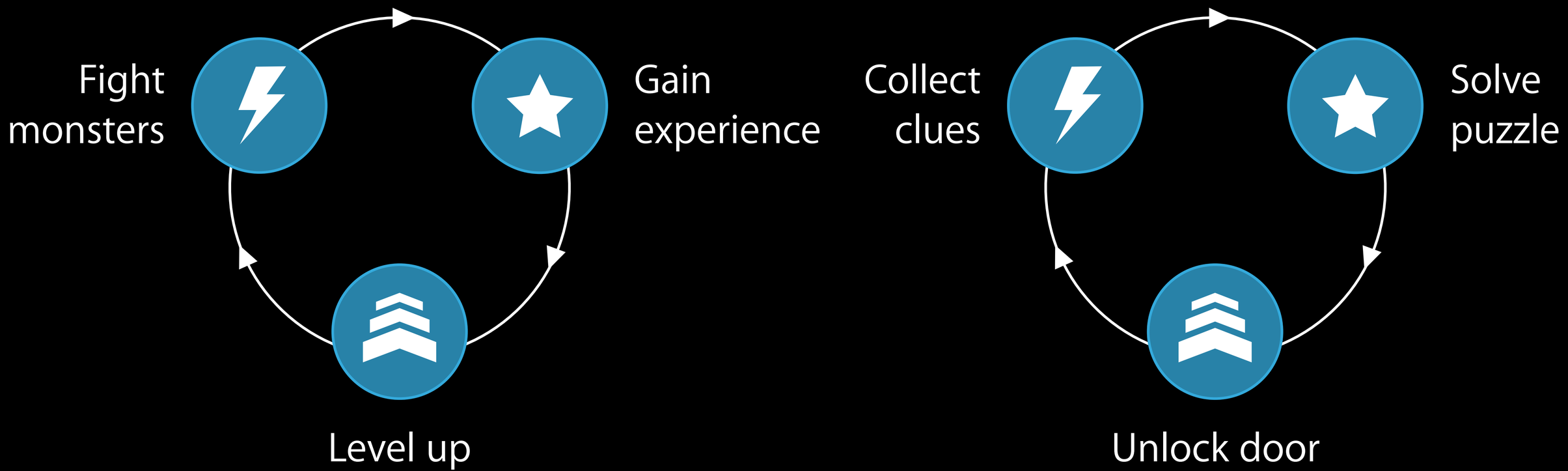
Core Loop

Platformer



Core Loop

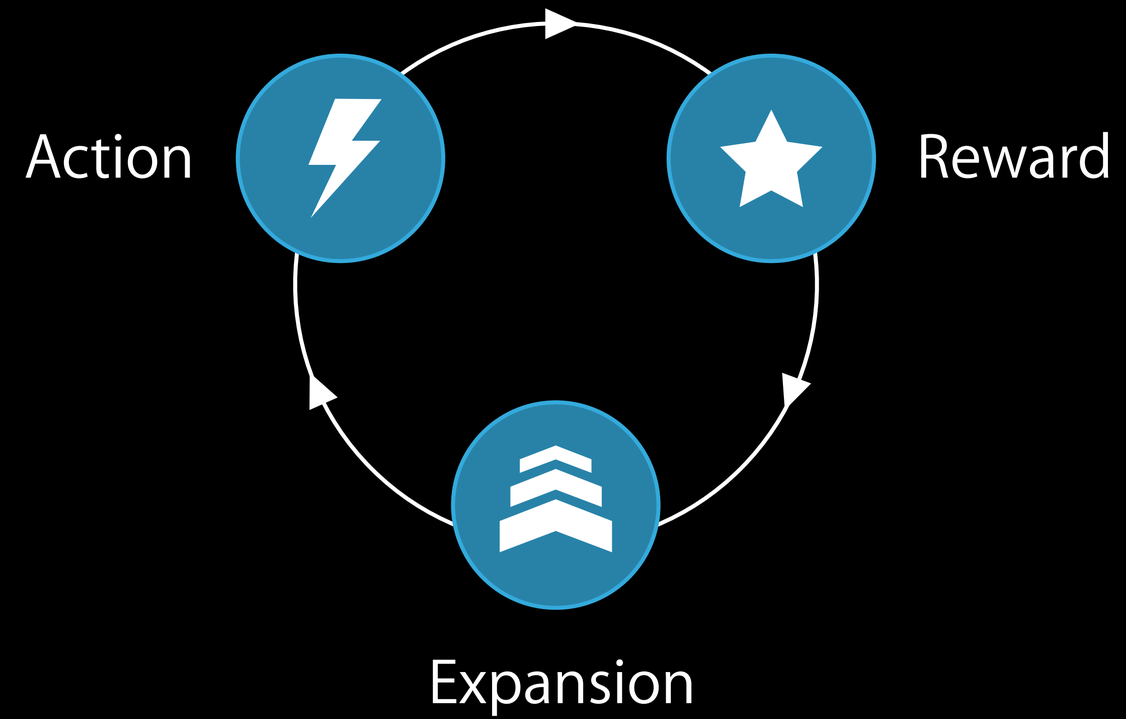
Multiple loops



Tune Your Core Loop

Key takeaways

Center on target audience

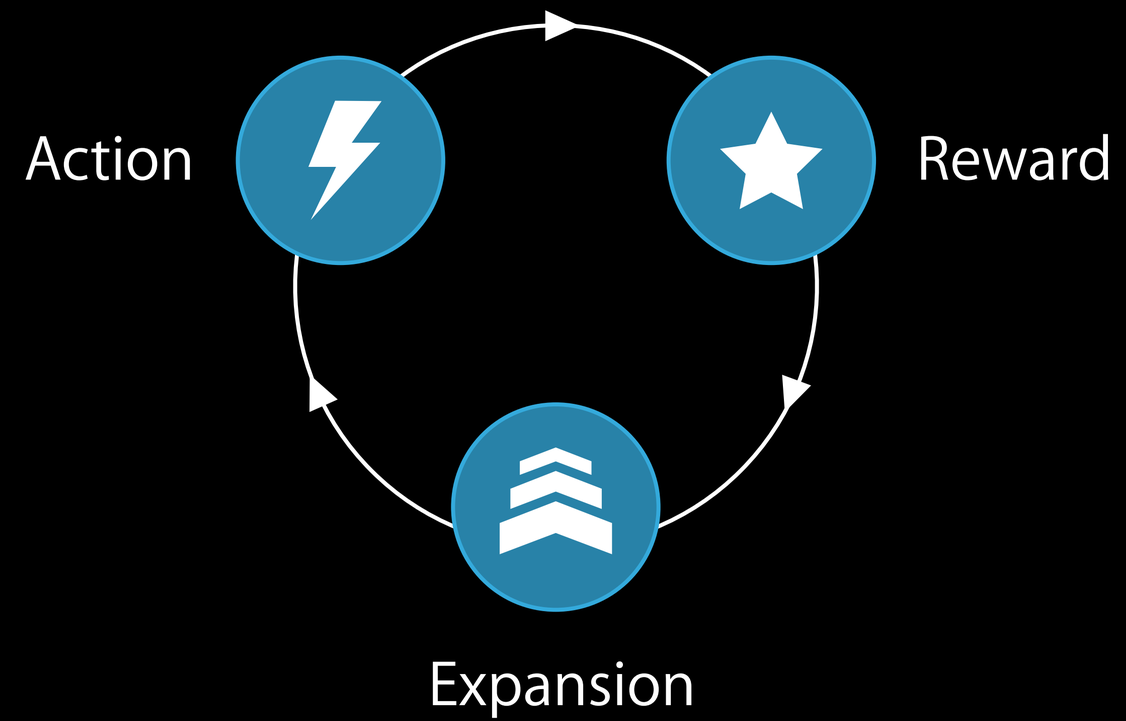


Tune Your Core Loop

Key takeaways

Center on target audience

Make it easy to understand



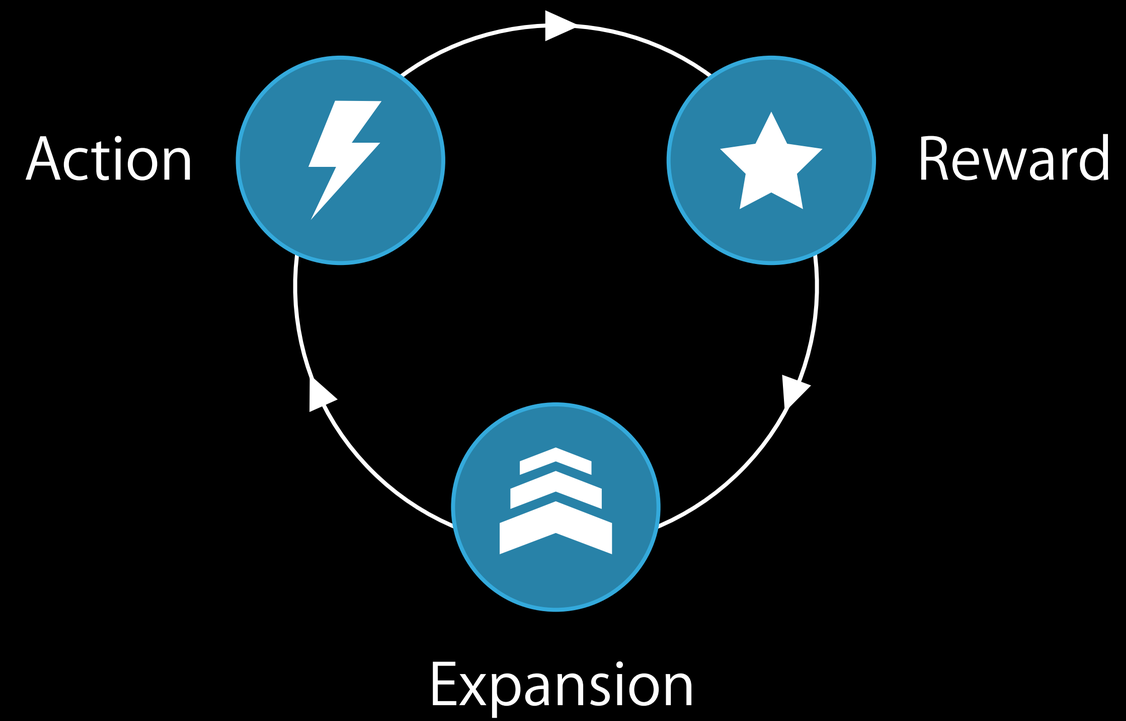
Tune Your Core Loop

Key takeaways

Center on target audience

Make it easy to understand

Steer each phase into the next



Tune Your Core Loop

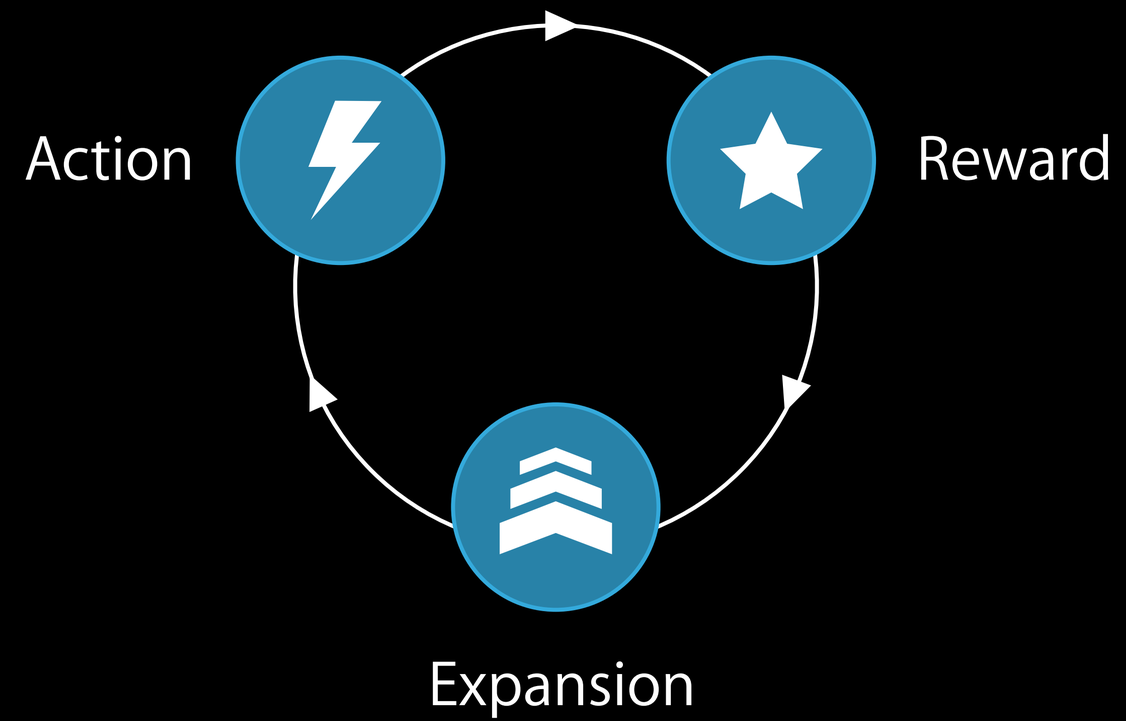
Key takeaways

Center on target audience

Make it easy to understand

Steer each phase into the next

Make iteration meaningful



Tune Your Core Loop

Key takeaways

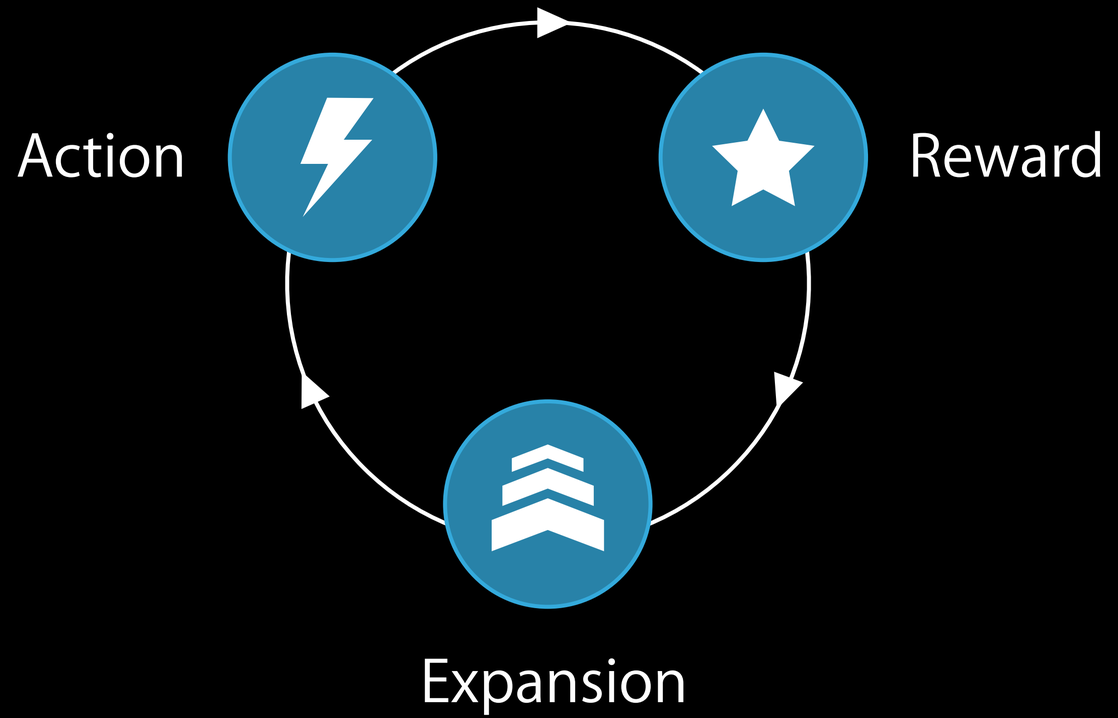
Center on target audience

Make it easy to understand

Steer each phase into the next

Make iteration meaningful

Question your assumptions



Tune Your Core Loop

Key takeaways

Center on target audience

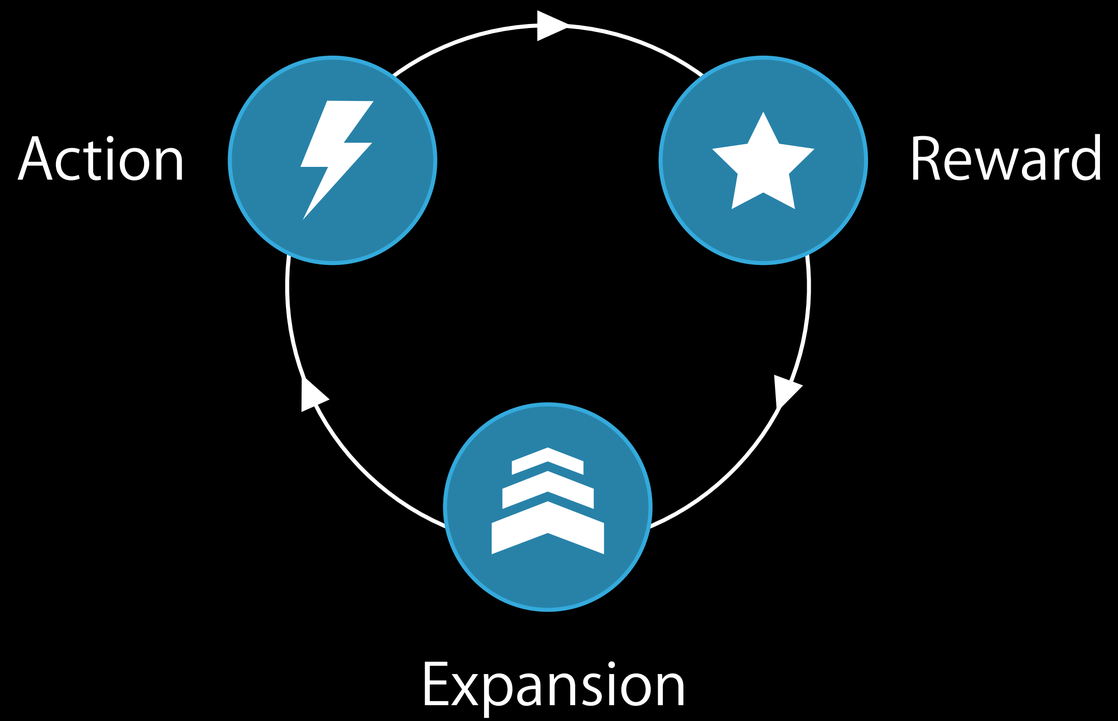
Make it easy to understand

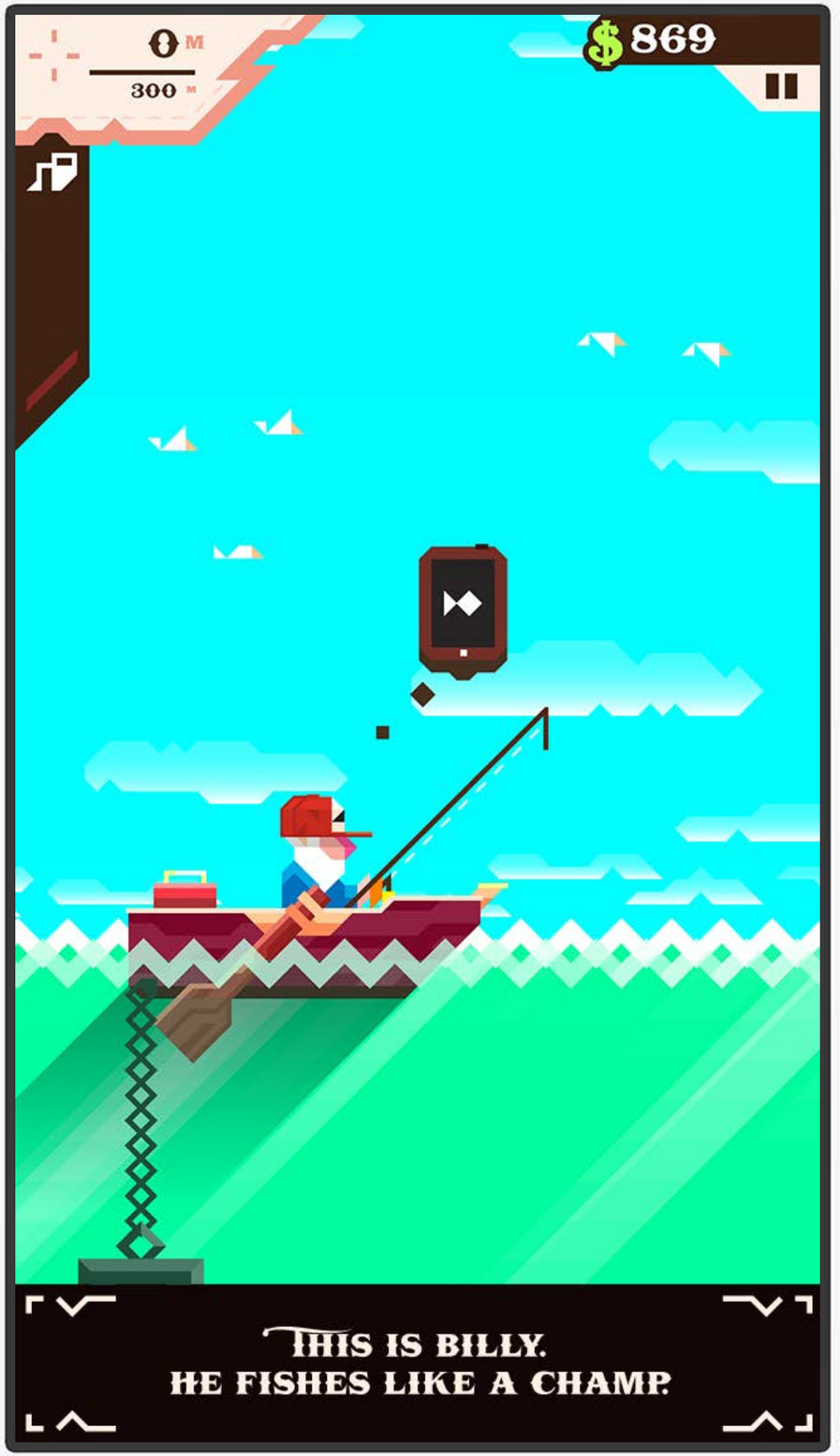
Steer each phase into the next

Make iteration meaningful

Question your assumptions

Don’t get boxed in



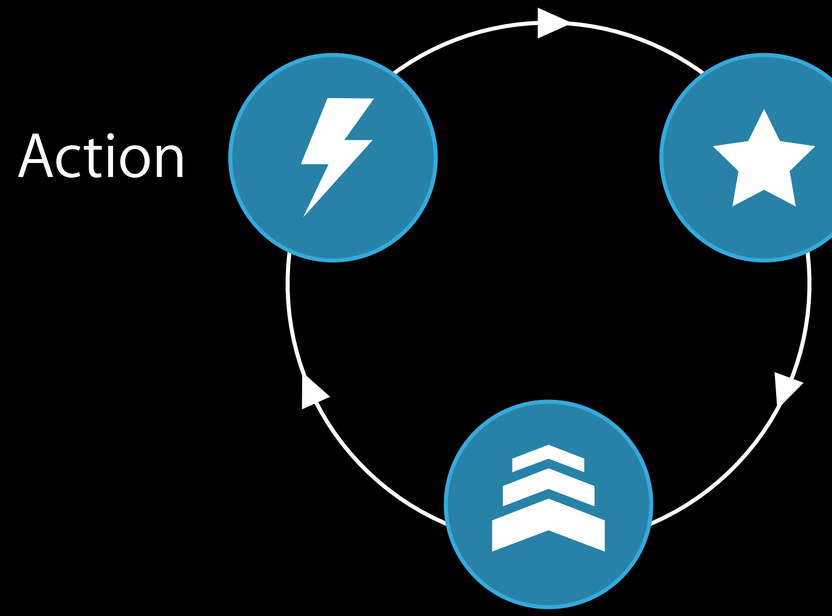

0 M
300 M
$ 869
THIS IS BILLY.
HE FISHES LIKE A CHAMP.

147 M
200 M
$ 889
TILT YOUR HOOK TO AVOID FISH,
& GO AS DEEP AS POSSIBLE.

ON THE WAY UP,
CATCH ALL THE FISH YOU CAN.

0 M
500 M
$3,554
$76
$5
NOW GRAB YOUR GUN &
SHOOT THE GILLS OFF 'EM!

1. Remove Friction
2. Be a Good Teacher
3. Tune Your Core Loop


Action
Reward
Expansion

Interaction mechanic

Action

Reward

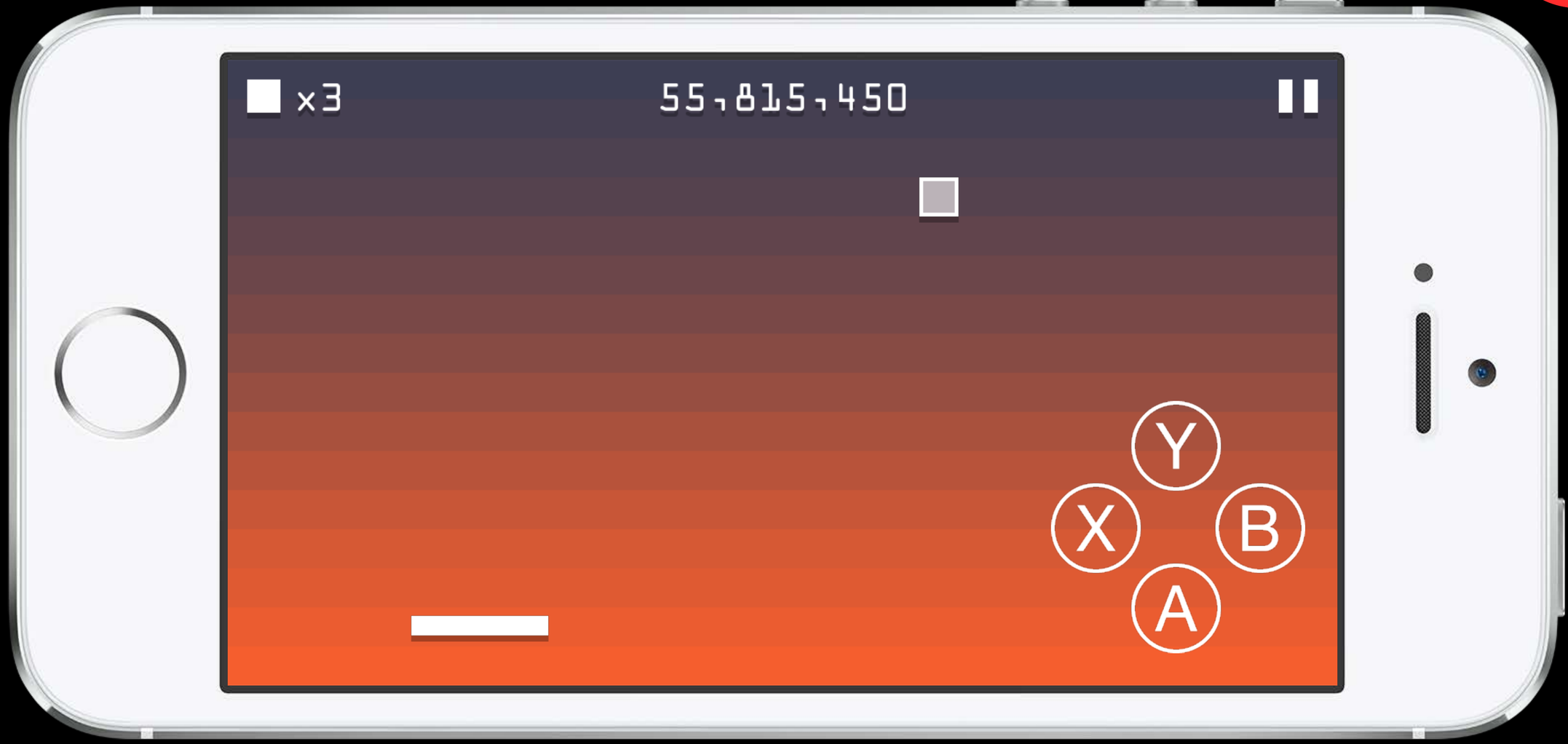
Expansion

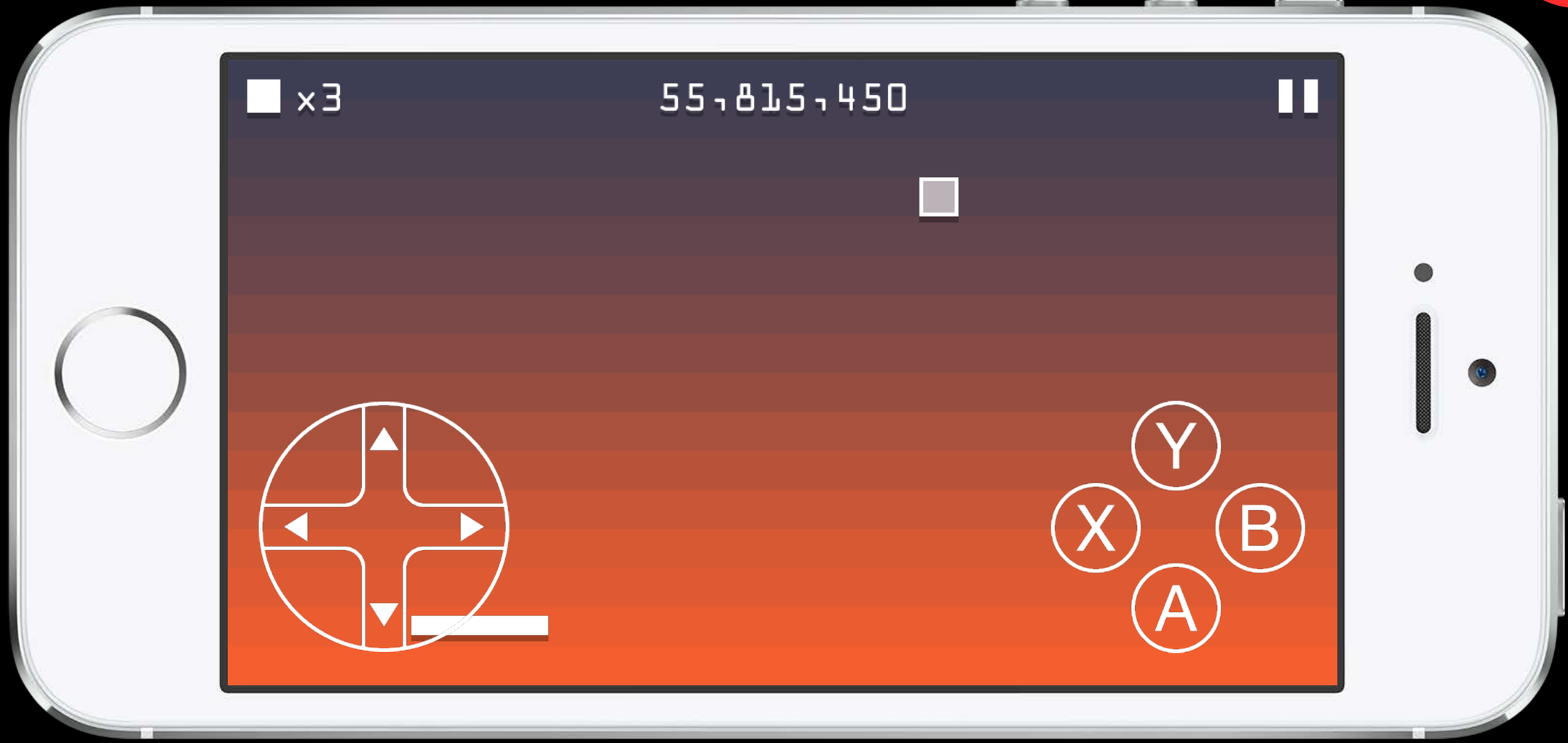
Expansion mechanic

Progression mechanic

4

Design for Touch


x3
55,815,450
Y
X
B
A


x3
55,815,450
Y
X
B
A

Interaction mechanic

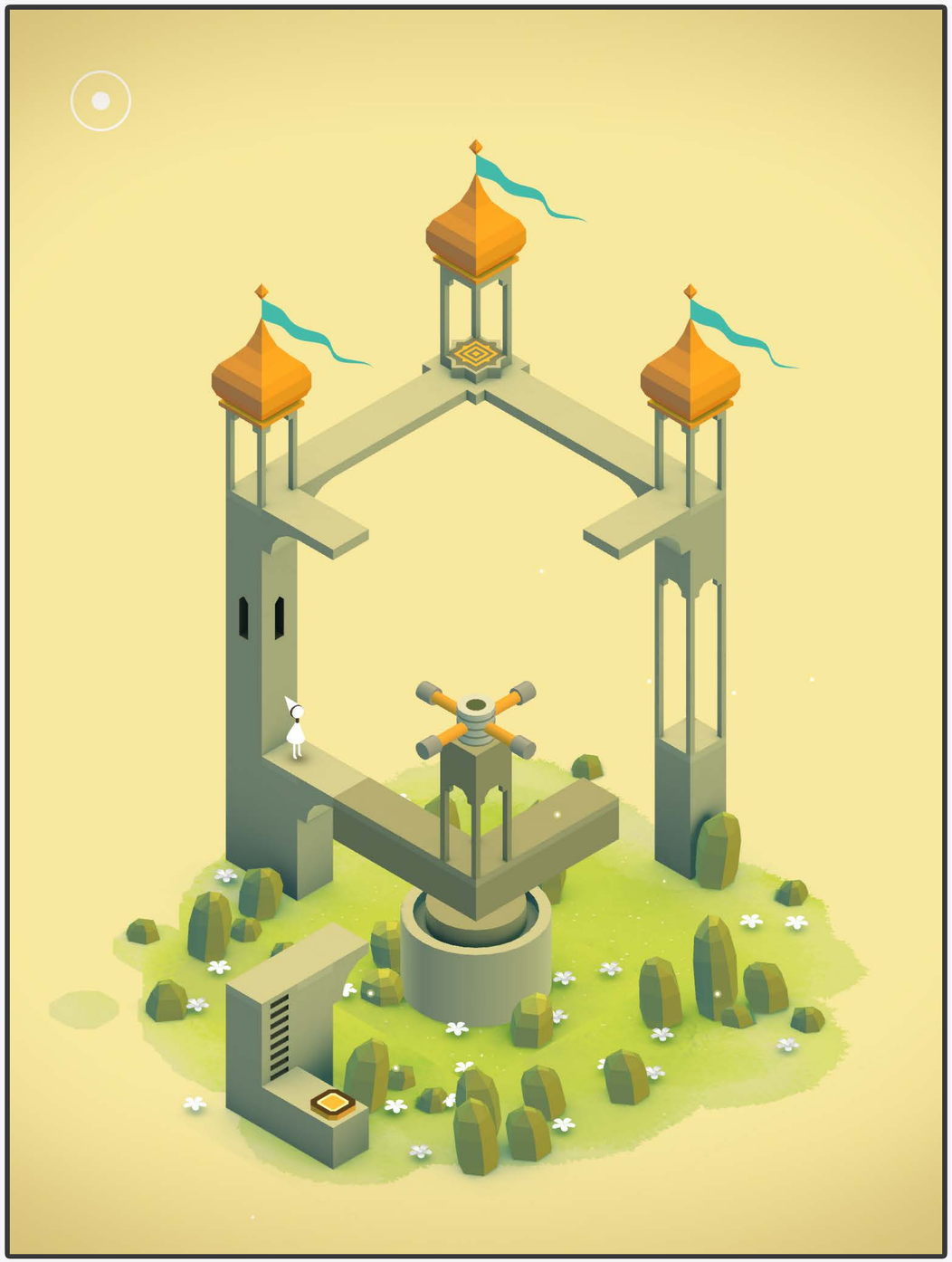
Action

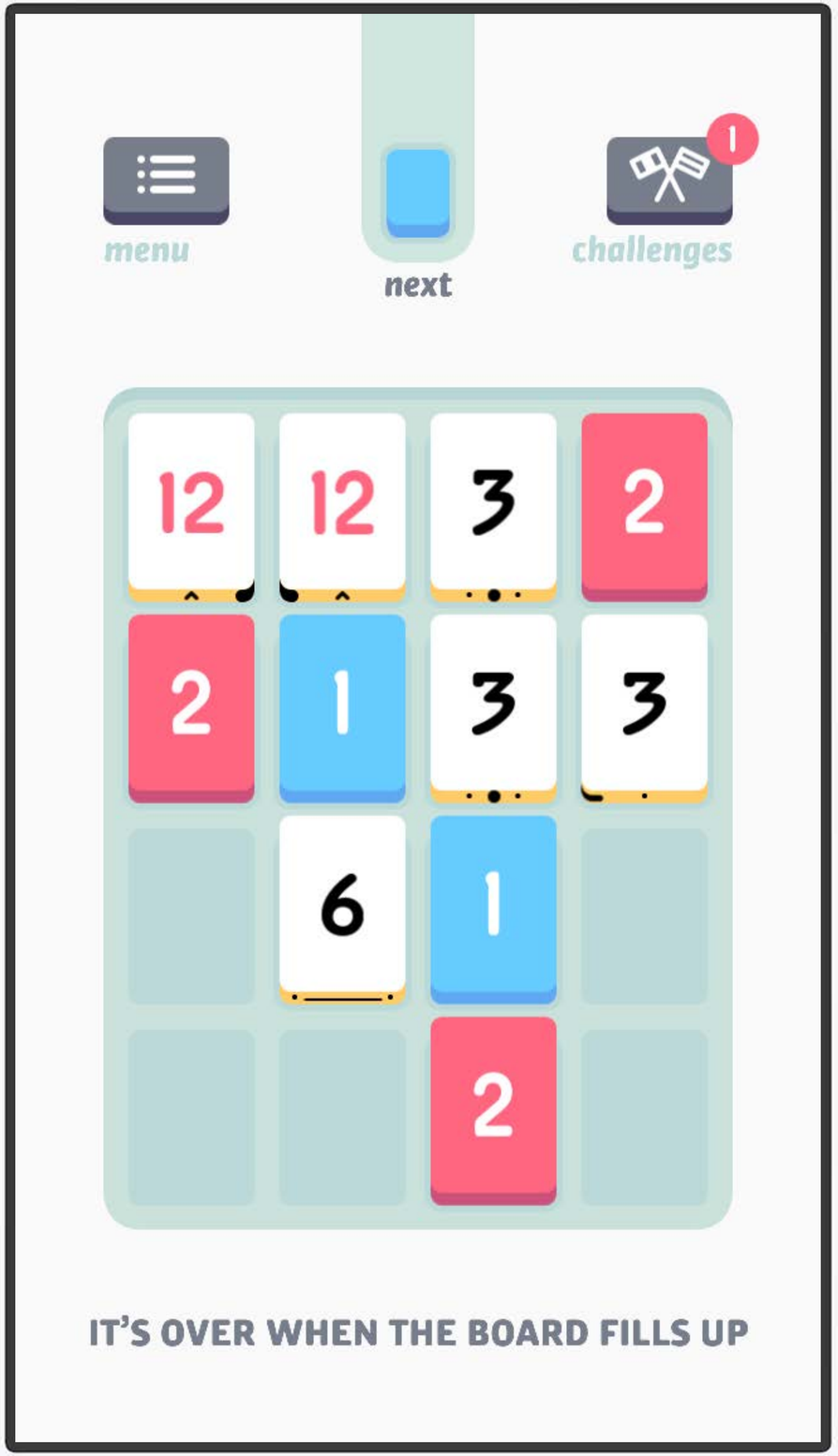
Reward

Expansion

Expansion mechanic

Progression mechanic




menu
next
challenges
1
12
12
3
2
2
1
3
3
6
1
2
IT'S OVER WHEN THE BOARD FILLS UP

MENU

Direct Interaction

Instantaneous Feedback

Design for Touch

Direct interaction

- Touches, taps
- Gestures, swipes
- Panning, paths

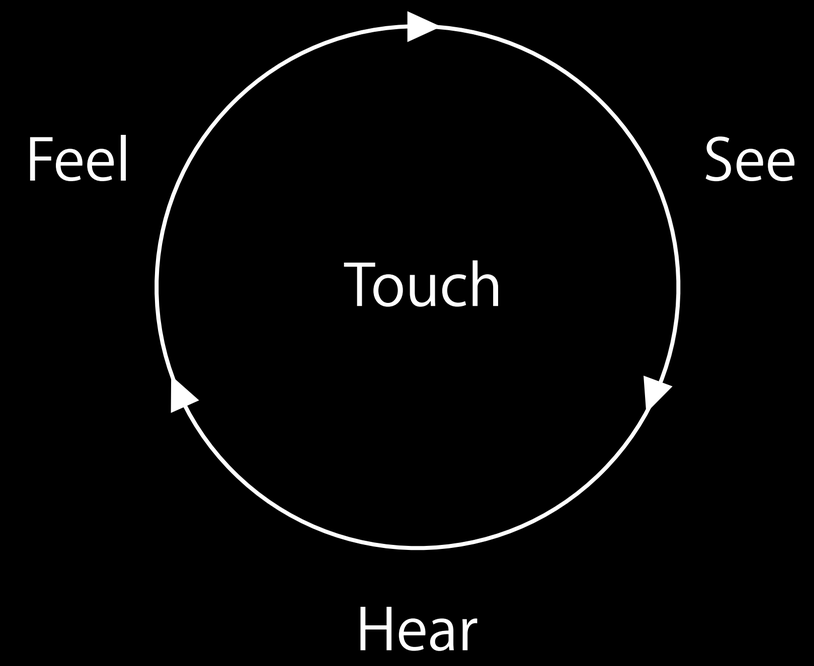
Design for Touch

Direct interaction

- Touches, taps
- Gestures, swipes
- Panning, paths

Instantaneous feedback

- Visual cues
- Audio cues



1. Remove Friction
2. Be a Good Teacher
3. Tune Your Core Loop
4. Design for Touch

Foster Engagement

Engagement

User Acquisition Replayability Customization Feedback

Reward Compulsion Loop Competition Balance Leveling

Virality Progression

Grinding Challenge

Engagement

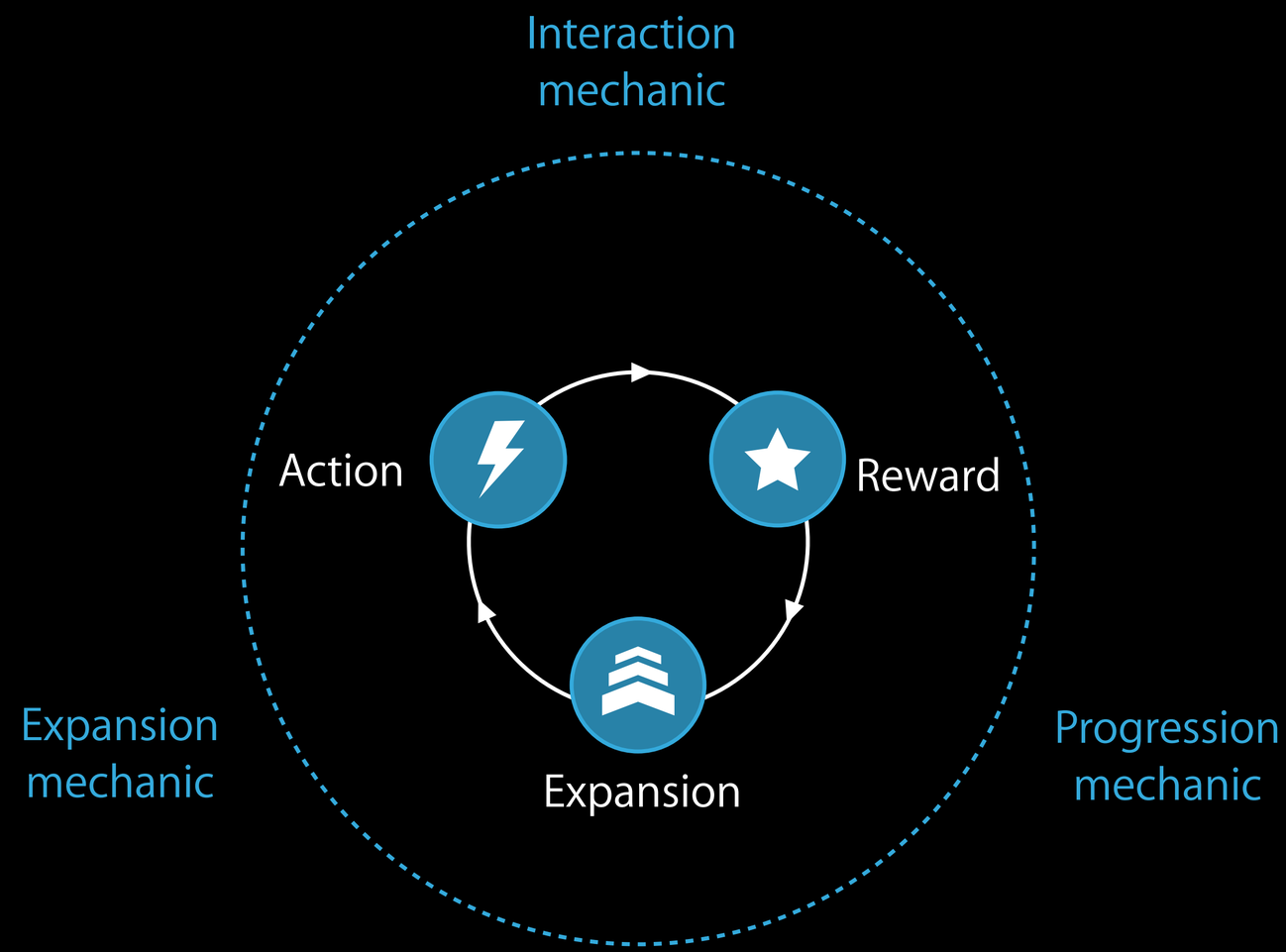
Sticky Addictive!

Prestige Balance

Word of Mouth Metagame Retention Achievement Core Loop

Gamification Intrinsic Motivators Play testing Funnel Validation

Engagement

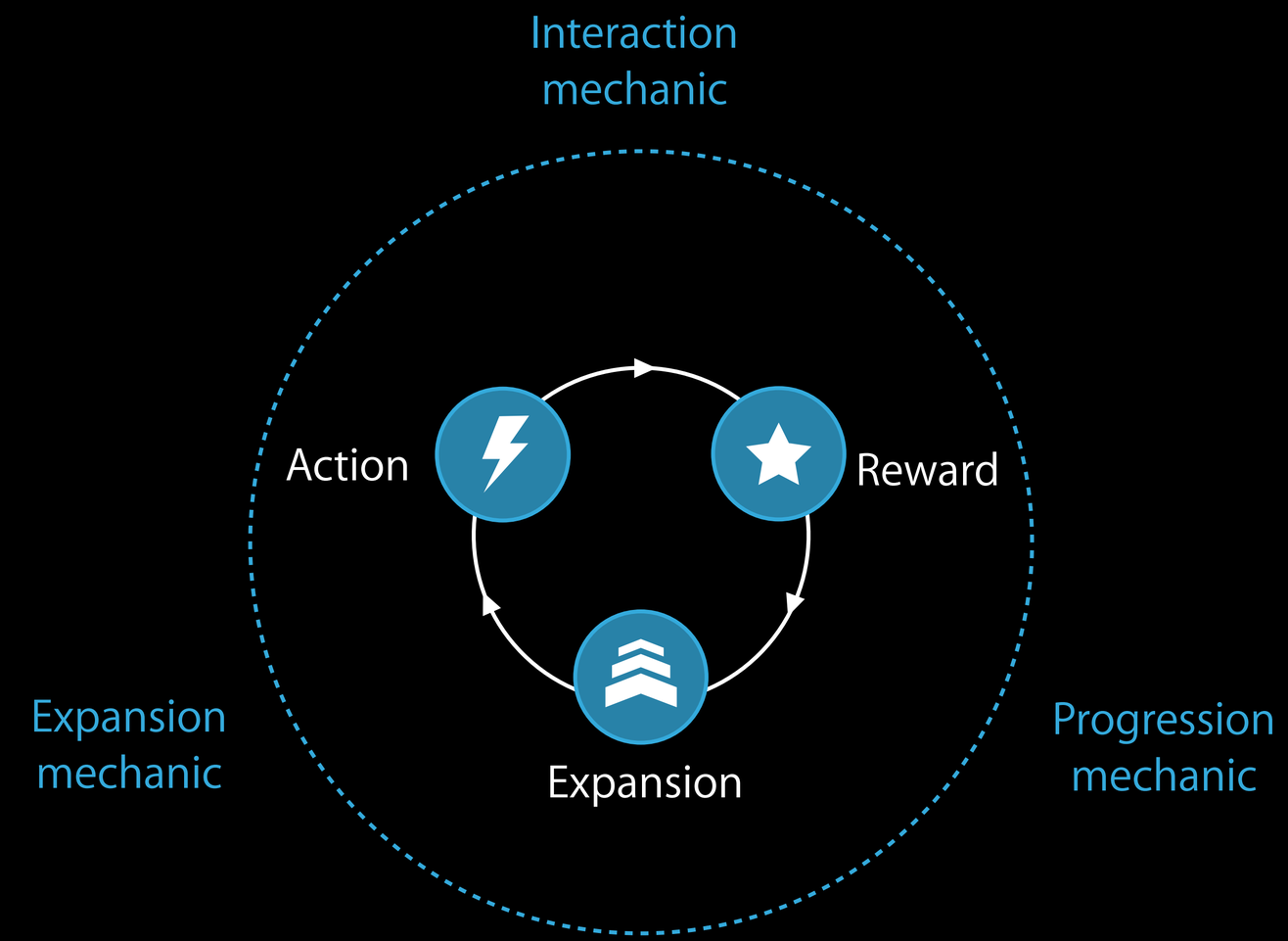

Interaction
mechanic
Action
Reward
Expansion
Expansion
mechanic
Progression
mechanic

Engagement

Holding the player's interest

Provide layers

- Parallel goals and challenges
- Multiple paths for risk vs. reward

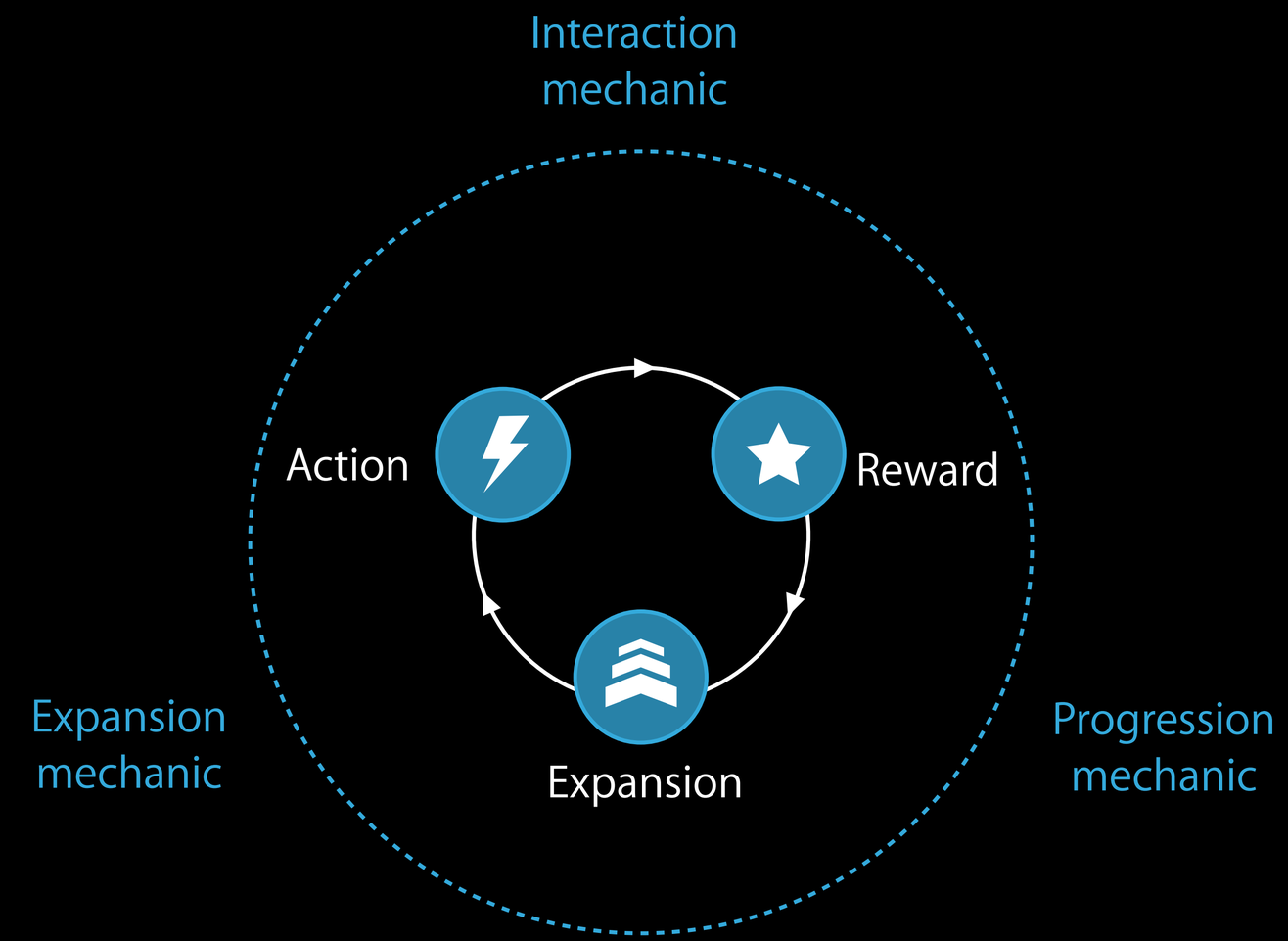


Engagement

Holding the player's interest

Provide value for everyone

- Paying and non-paying players

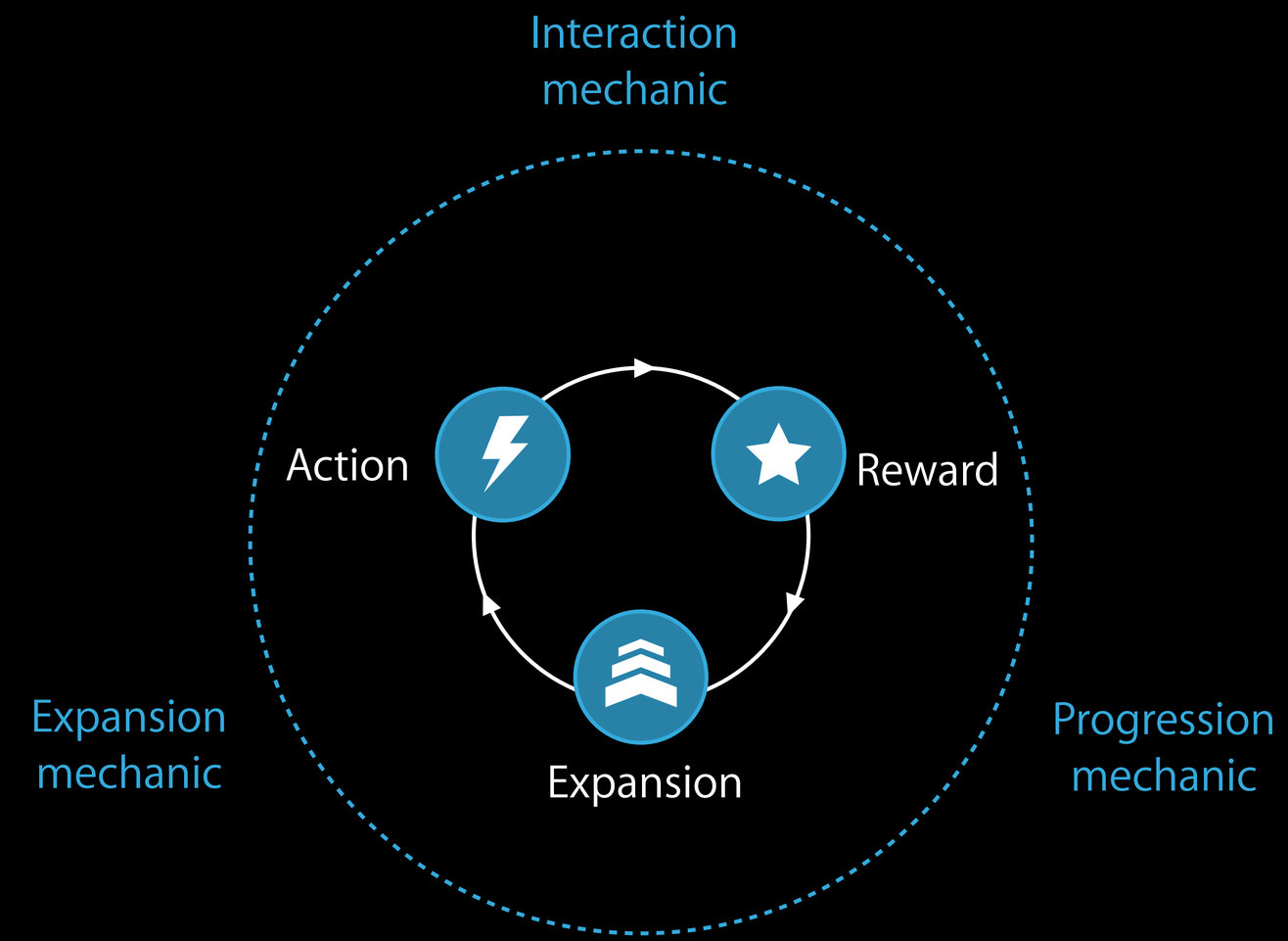


Engagement

Holding the player's interest

Incentivize repeat play

- Motivate "One more try"
- Motivate "See what's next"
- Motivate "See how it ends"



Re-Engagement

Updates

Provide fresh content

- Continuing storyline
- New game levels
- New challenges
- Seasonal content

Plan your updates before launch

itunesconnect.apple.com

iTunes Connect My Apps

Jane Appleseed
App Co.

< Apps

Manage | Sales and Trends

Paddle Mania 3000

Metrics | Sources | Retention

Filter

Daily

Date	Installs	1	2	3	4	5	6	7	8	9	10	11	12
May 23	1021	43%	42%	31%	28%	26%	22%	18%	16%	9%	7%	5%	3%
May 24	1091	42%	41%	36%	34%	27%	24%	17%	14%	8%	7%	6%	
May 25	1132	45%	41%	34%	32%	29%	23%	19%	13%	10%	8%		
May 26	1364	43%	40%	35%	30%	22%	18%	16%	16%	9%			
May 27	1481	41%	38%	33%	31%	29%	22%	17%	14%				
May 28	1555	45%	42%	35%	33%	24%	24%	19%					
May 29	1672	46%	43%	37%	34%	26%	23%						
May 30	1843	42%	40%	33%	32%	27%							
May 31	1901	46%	41%	33%	31%								
Jun 1	1987	51%	40%	35%									
Jun 2	2001	53%	41%										
Jun 3	2144	50%											

1. Remove Friction
2. Be a Good Teacher
3. Tune Your Core Loop
4. Design for Touch
5. Foster Engagement

Use Background Transfers

In the Bundle

Paddle Mania 3000

Thousands of image assets

- Retina and non-retina
- iPad and iPhone

Sounds

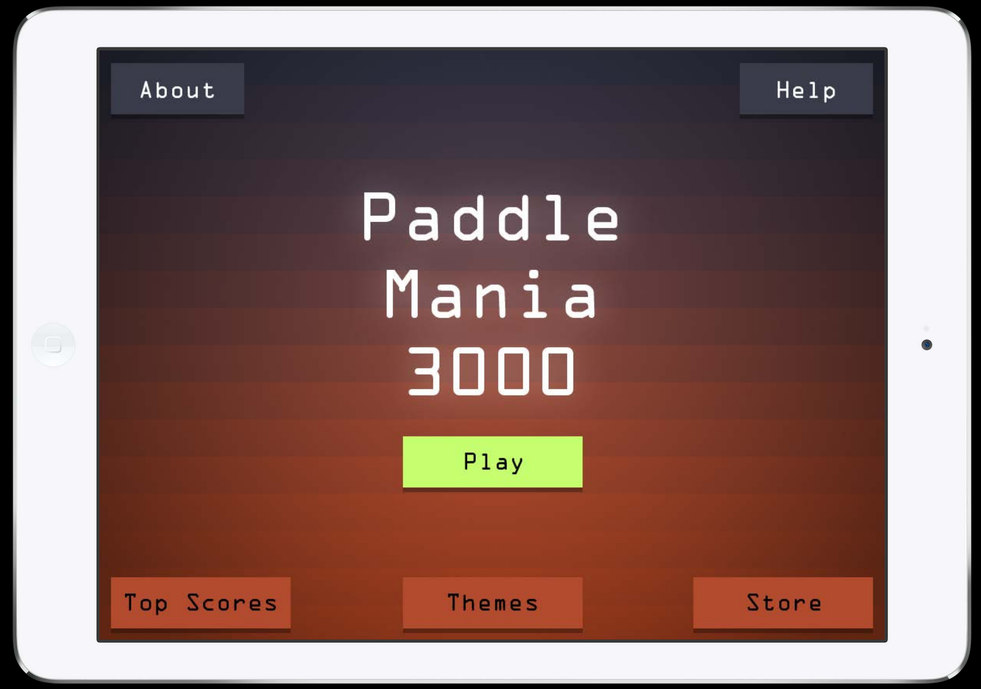
- AAC, MP3, LPCM

Localizations

- EFIGS+8

Binary

- armv7, armv7s, arm64



This item is over 100MB.

Paddle Mania 3000 will not download until you connect to Wi-Fi.

Cancel | **OK**

“One size fits all!”

“One size fits all!”

Don’t Sacrifice Quality

Use Background Transfers

Background Transfers

Strategy

Segment your assets

- Bundled content
- Content to download after first launch

For example

- First set of levels at full quality
- More levels as player progresses

Background Transfers

With NSURLSession

Service to upload and download data

Transfer done out of process

App relaunched when transfer completes

Background Transfers

With NSURLSession

Service to upload and download data

Transfer done out of process

App relaunched when transfer completes

Adds complexity

Background Transfers

With NSURLSession

Service to upload and download data

Transfer done out of process

App relaunched when transfer completes

Adds complexity

Follow the iOS Data Storage Guidelines

1. Remove Friction
2. Be a Good Teacher
3. Tune Your Core Loop
4. Design for Touch
5. Foster Engagement
6. Use Background Transfers

Optimize Graphics Performance

Optimize Graphics Performance

OpenGL ES

Most common issue

- Too many draw calls
- Too few triangles per draw call

Optimize Graphics Performance

OpenGL ES

Most common issue

- Too many draw calls
- Too few triangles per draw call

Worst-case scenario

- Bind a texture
- Draw one quad
- Repeat

Optimize

Eliminate redundant state changes

Combine textures into atlases

Maximize triangles per batch

Provide longer vertex arrays

Modify state lazily

Prewarm shaders

Optimize

Join short strips

Use instancing

Cull offscreen objects

Hoist work upstream

Flatten transformations

Minimize small batches

Sort rendering by state

Discard buffers

Light Prepass

LightPrepass 〉 iPad Mini

Running LightPrepass on iPad Mini 57

LightPrepass
Captured GPU Frame

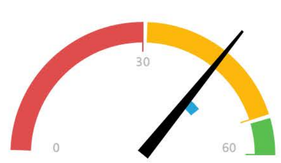
FPS	45 FPS
Program #14 "Light"	9.72 ms
Program #3 "Material"	9.67 ms
Program #2 "GBuffer"	3.22 ms
Program #6 "Skybox"	0.32 ms
Program #5 "Fairy"	0.07 ms
Program #1 "ZOnly"	0.03 ms

Graphics Report

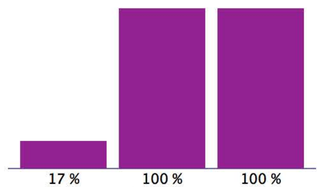
Graphics

Analyze

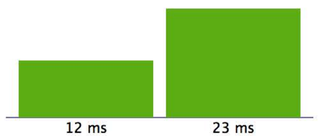
Frames Per Second 43



Utilization



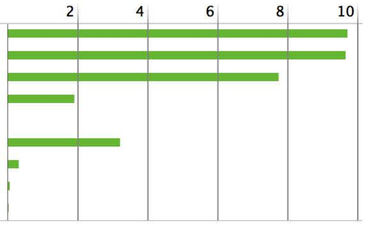
Frame Time



Program Performance

Current ms

Program	Frame %	Current ms
Program #14 "Light"	42.2%	9.72
Program #3 "Material"	42.0%	9.67
2550 glDrawElements(GL_TRIANGLES, 61266, GL_UNS…	33.7%	7.75
2558 glDrawElements(GL_TRIANGLES, 21006, GL_UNS…	8.3%	1.91
2566 glDrawElements(GL_TRIANGLES, 48, GL_UNSIGN…	0.0%	0.00
Program #2 "GBuffer"	14.0%	3.22
Program #6 "Skybox"	1.4%	0.32
Program #5 "Fairy"	0.3%	0.07
Program #1 "ZOnly"	0.1%	0.03
Total		23.04



Automatic 〉 Program #3 "Material" 〉 Fragment Shader

```
    lowp vec4 light = texture2DProj(light_texture,
        v_lightcoord);

    lowp vec3 diffuse = light.rgb;
    lowp vec3 specular = vec3(light.a);
//    lowp vec3 specular = light.rgb * max(light.a /
    length(light.rgb), 0.0);

    mediump vec3 n_s = texture2DProj(gbuffer_texture,
        v_lightcoord).rgb;
    float sun_atten = shadow2DProjE                    59.3%
        (shadow_texture, v_shadowcoord);
    float sun_diffuse = max(dot(n_s * 2.0 - 1.0        18.8%
        sun_direction), 0.0) * sun_atten;

    diffuse += sun_color * sun_diffuse;                5.2%

    diffuse *= texture2D(diffuse_texture, v_texcoord.x
        ).rgb;
    specular *= texture2D(specular_texture, v_texcoor
        xy).rgb;

    diffuse += diffuse;                                6.5%
    specular += specular;                              4.2%

    gl_FragColor = vec4(diffuse + specular, 1.0);
}
```

2566 glDrawElements(GL_TRIANGLES, 48, GL_UNSIGNED_SHORT, 0x000282c0)

Auto

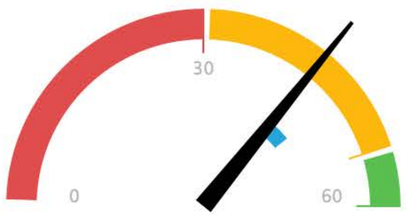
GL Context

Graphics Report

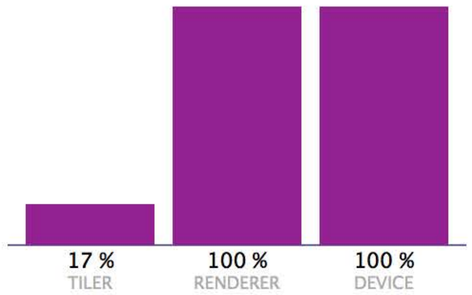
Graphics

Analyze

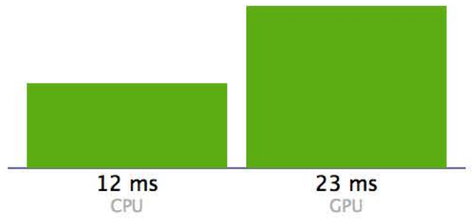
Frames Per Second 43



Utilization



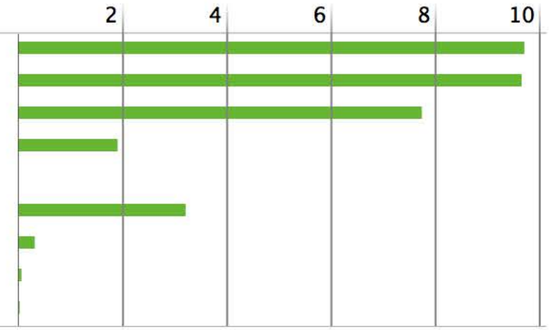
Frame Time



Program Performance

● Current ms

Program	Frame %	Current ms
▶ Program #14 "Light"	42.2%	9.72
▼ Program #3 "Material"	42.0%	9.67
2550 glDrawElements(GL_TRIANGLES, 61266, GL_UNS…	33.7%	7.75
2558 glDrawElements(GL_TRIANGLES, 21006, GL_UNS…	8.3%	1.91
2566 glDrawElements(GL_TRIANGLES, 48, GL_UNSIGN…	0.0%	0.00
▶ Program #2 "GBuffer"	14.0%	3.22
▶ Program #6 "Skybox"	1.4%	0.32
▶ Program #5 "Fairy"	0.3%	0.07
▶ Program #1 "ZOnly"	0.1%	0.03
Total		23.04



Light Prepass — LightPrepass.gputrace

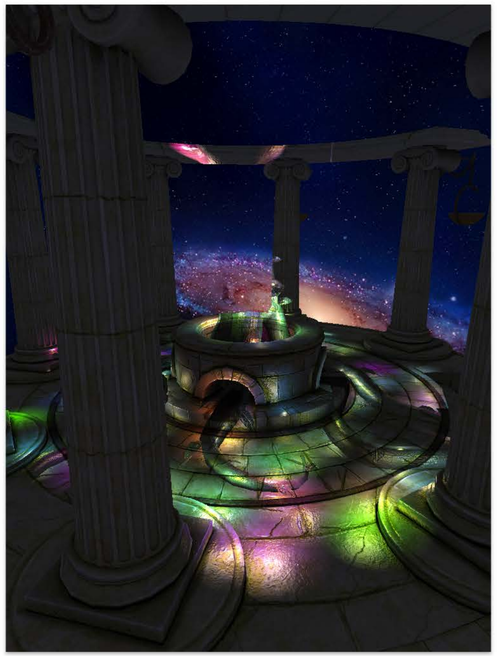
LightPrepass › iPad Mini

Running LightPrepass on iPad Mini 57

LightPrepass
Captured GPU Frame

FPS	45 FPS
Program #14 "Light"	9.72 ms
Program #3 "Material"	9.67 ms
Vertex Shader	0.12 ms
Fragment Shader	9.55 ms
Draws	
2550 glDrawEle…	7.75 ms
2558 glDrawEle…	1.91 ms
2566 glDrawEle…	0.00 ms
Program #2 "GBuffer"	3.22 ms
Program #6 "Skybox"	0.32 ms
Program #5 "Fairy"	0.07 ms
Program #1 "ZOnly"	0.03 ms

2550 glDrawElements(GL_TRIANGLES, 61266, GL_…



Color Attachment 0

Bound GPU Objects › All › Program #3 "Material" › Fragment Shader 6

```
varying highp vec4 v_lightcoord;
varying highp vec4 v_shadowcoord;
varying highp vec4 v_texcoord;

void main()                                                          6.0%
{
    lowp vec4 light = texture2DProj(light_texture, v_lightcoord);

    lowp vec3 diffuse = light.rgb;
    lowp vec3 specular = vec3(light.a);

    mediump vec3 n_s = texture2DProj(gbuffer_texture, v_lightcoord).rgb;
    float sun_atten = shadow2DProjEXT                               59.3%
        (shadow_texture, v_shadowcoord);
    float sun_diffuse = max(dot(n_s * 2.0 - 1.0, sun_direction),    18.8%
        0.0) * sun_atten;

    diffuse += sun_color * sun_diffuse;                              5.2%

    diffuse *= texture2D(diffuse_texture, v_texcoord.xy).rgb;
    specular *= texture2D(specular_texture, v_texcoord.xy).rgb;

    diffuse += diffuse;                                              6.5%
    specular += specular;                                            4.2%

    gl_FragColor = vec4(diffuse + specular, 1.0);
}
```

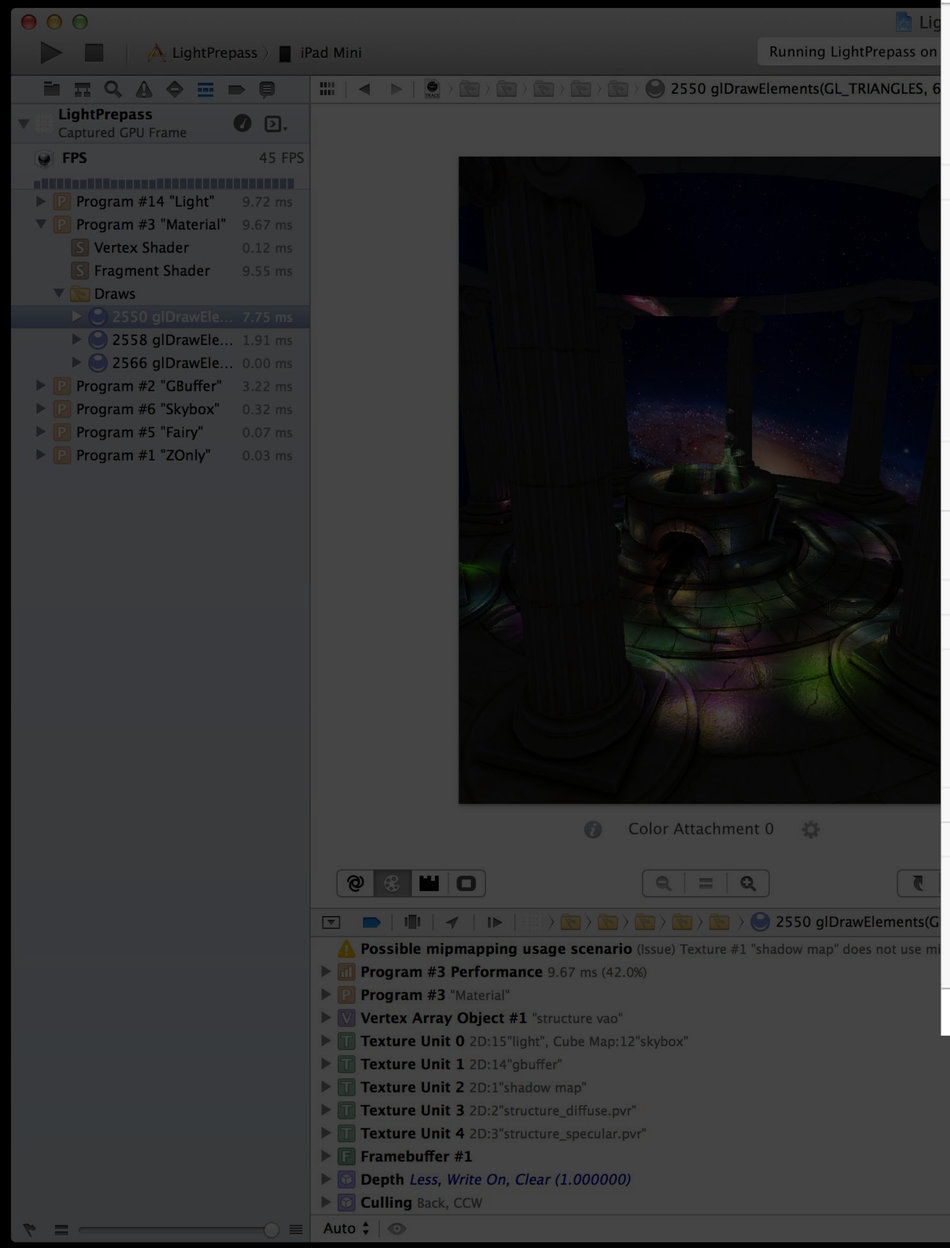
2550 glDrawElements(GL_TRIANGLES, 61266, GL_UNSIGNED_SHORT, NULL)

- **Possible mipmapping usage scenario** (Issue) Texture #1 "shadow map" does not use mipmaps, and could possibly benefit from mip…
- **Program #3 Performance** 9.67 ms (42.0%)
- **Program #3** "Material"
- **Vertex Array Object #1** "structure vao"
- **Texture Unit 0** 2D:15"light", Cube Map:12"skybox"
- **Texture Unit 1** 2D:14"gbuffer"
- **Texture Unit 2** 2D:1"shadow map"
- **Texture Unit 3** 2D:2"structure_diffuse.pvr"
- **Texture Unit 4** 2D:3"structure_specular.pvr"
- **Framebuffer #1**
- **Depth** *Less, Write On, Clear (1.000000)*
- **Culling** Back, CCW

Auto

- **Error Status** No GL Error
- **Color** Write (RGBA), Clear (0.075, 0.075, 0.075, 1)
- **Blending** Off
- **Depth** *Less, Write On, Clear (1.000000)*
- **Stencil** Off
- **Multisampling** Default Coverage
- **Active Texture Unit** Texture Unit 0
- **Vertex Attribute Values**
- **Culling** Back, CCW
- **Viewport** (0, 0, 1536, 2048) – (0, 1)
- **Scissor** Off
- **Clip Distance** No Clip Distances Enabled

GL Context



ghtPrepass.gputrace

57

Bound GPU Objects 〉 All 〉 Program #3 "Material" 〉 Fragment Shader

6

```
varying highp vec4 v_lightcoord;
varying highp vec4 v_shadowcoord;
varying highp vec4 v_texcoord;

void main()                                                    6.0%
{
    lowp vec4 light = texture2DProj(light_texture, v_lightcoord);

    lowp vec3 diffuse = light.rgb;
    lowp vec3 specular = vec3(light.a);

    mediump vec3 n_s = texture2DProj(gbuffer_texture, v_lightcoord).rgb;
    float sun_atten = shadow2DProjEXT                          59.3%
        (shadow_texture, v_shadowcoord);
    float sun_diffuse = max(dot(n_s * 2.0 - 1.0, sun_direction),   18.8%
        0.0) * sun_atten;

    diffuse += sun_color * sun_diffuse;                        5.2%

    diffuse *= texture2D(diffuse_texture, v_texcoord.xy).rgb;
    specular *= texture2D(specular_texture, v_texcoord.xy).rgb;

    diffuse += diffuse;                                        6.5%
    specular += specular;                                      4.2%

    gl_FragColor = vec4(diffuse + specular, 1.0);
}
```

SpriteKit

SceneKit

SpriteKit

SceneKit

Metal

1. Remove Friction
2. Be a Good Teacher
3. Tune Your Core Loop
4. Design for Touch
5. Foster Engagement
6. Use Background Transfers
7. Optimize Graphics Performance

8

Make a Great Preview Video

9:41 AM 100%

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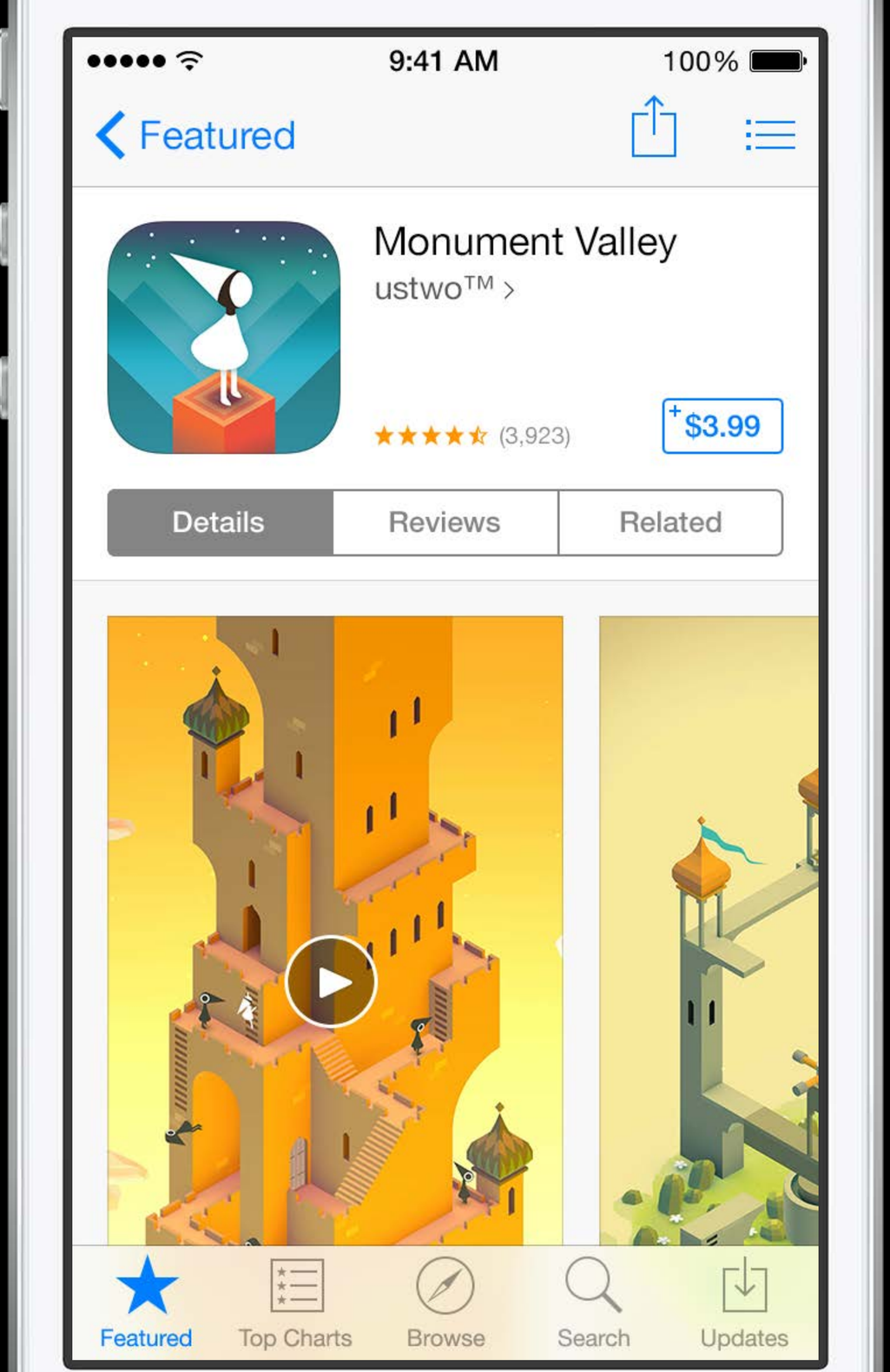
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(3,923)
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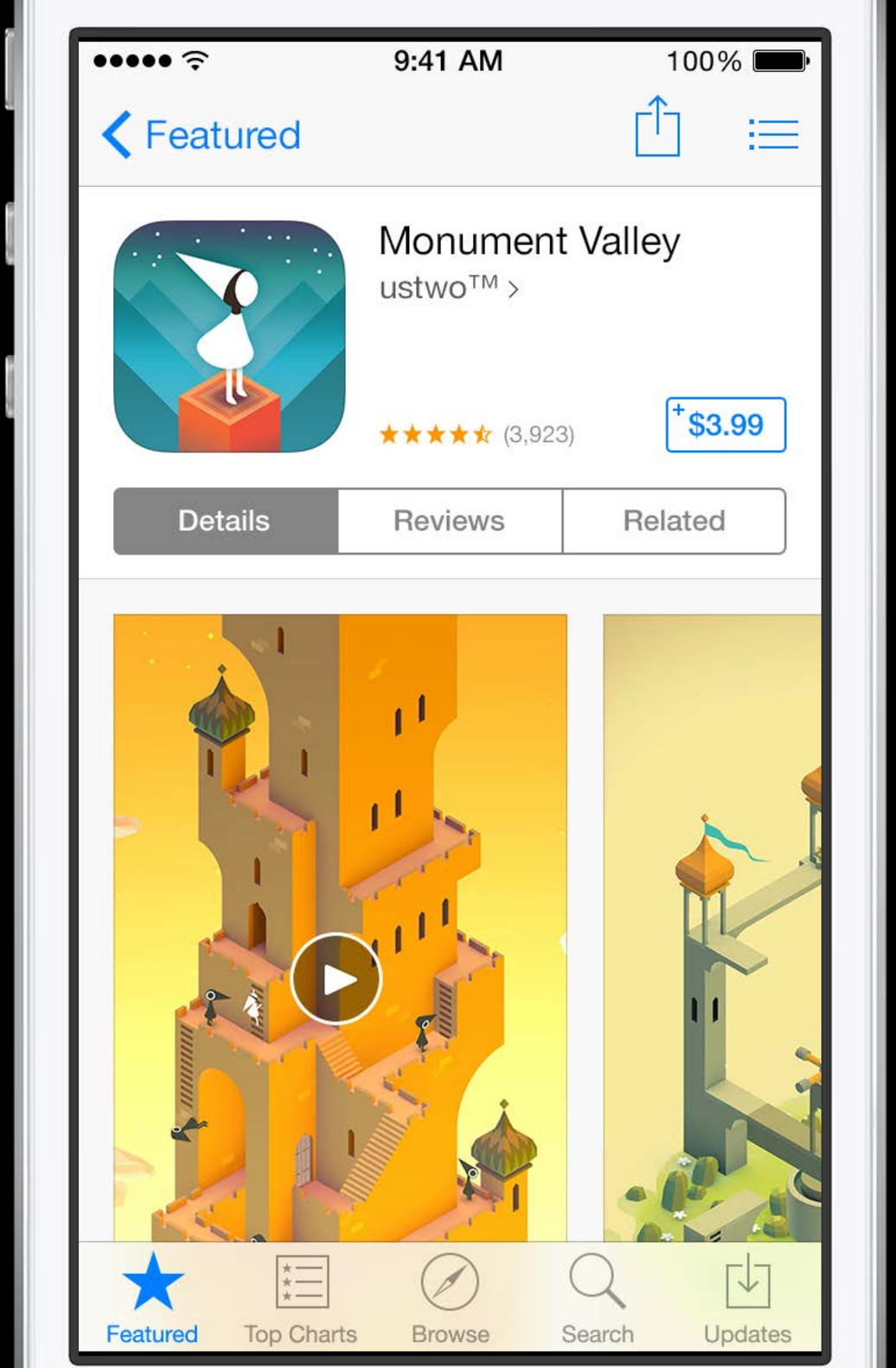
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Monument Valley
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(3,923)
$3.99
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Updates

App Previews

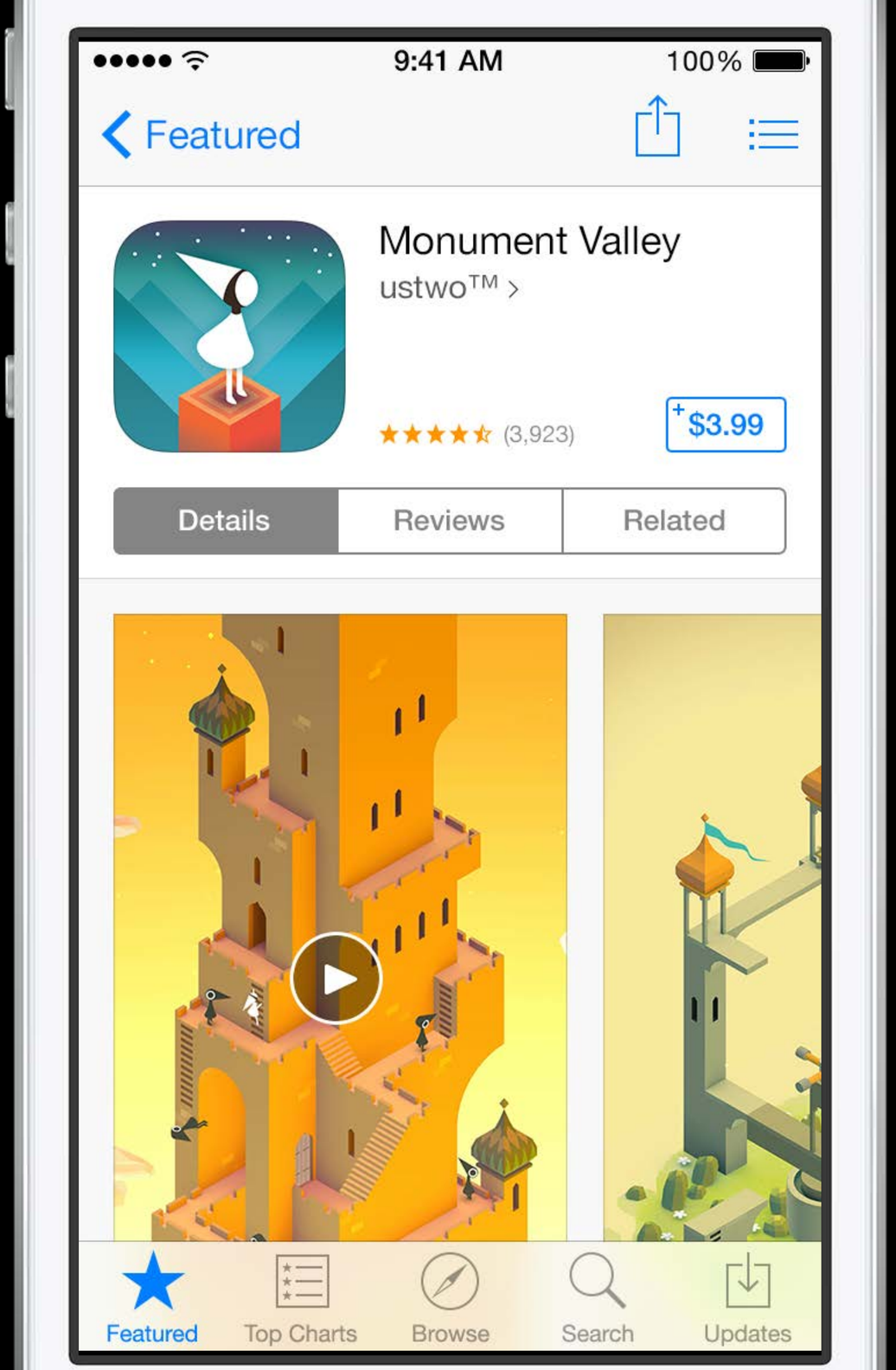
Gameplay video

Up to 30 seconds

Deliver in H.264 MPEG4

Capture directly from iOS 8

Edit with iMovie on OS X 10.10



App Previews

Enhance App Store presence

Icon

Name

Screenshots

App Previews

Localizations

Description

Keywords

1. Remove Friction
2. Be a Good Teacher
3. Tune Your Core Loop
4. Design for Touch
5. Foster Engagement
6. Use Background Transfers
7. Optimize Graphics Performance
8. Make a Great Preview Video

Localize

155 countries

More than 40 languages

Think Globally

Act Locally

Localize App Store metadata

Name

Description

Keywords

Screen snapshots

Act Locally

Localize app content

Structure for internationalization

Translate assets, user interface

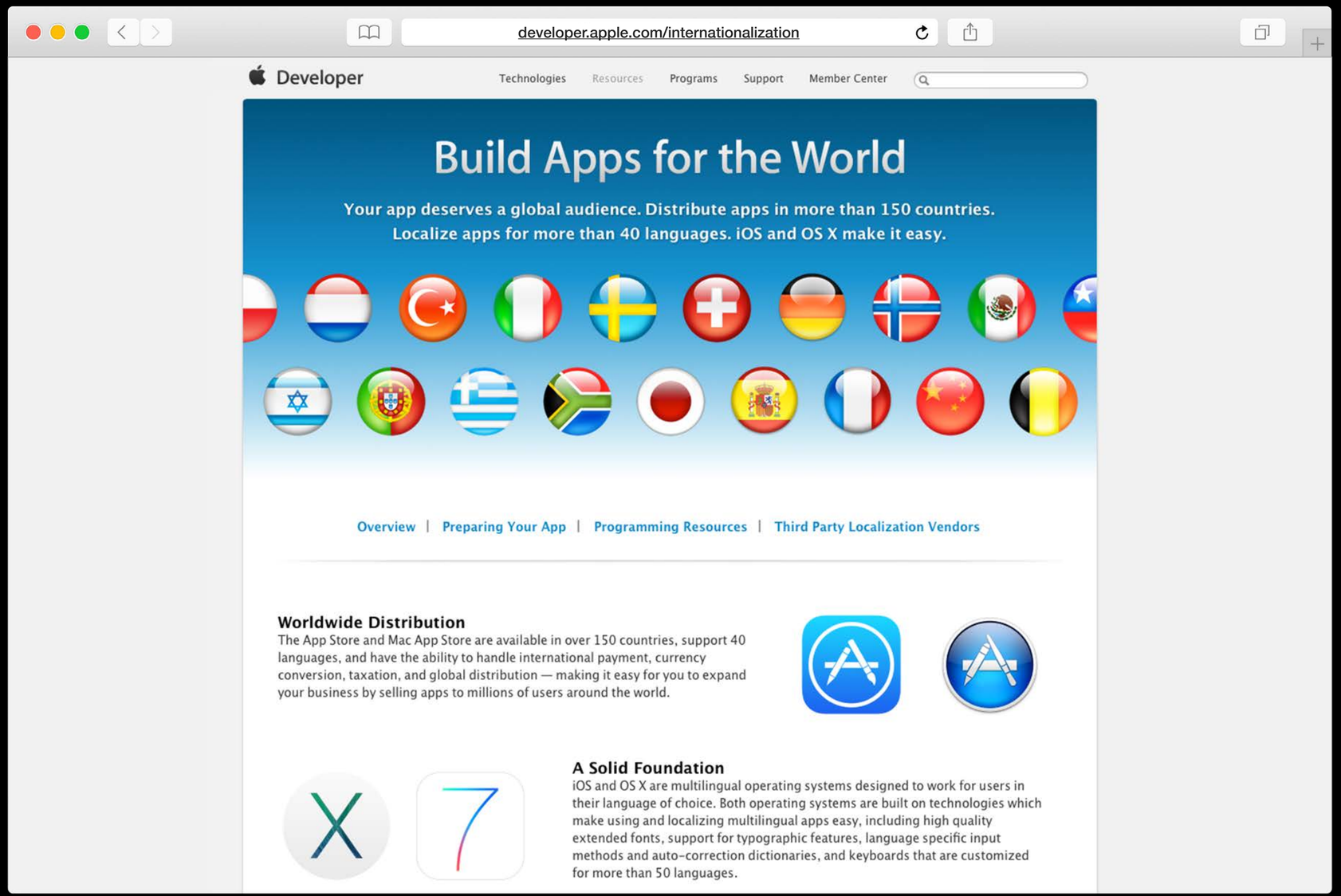
Culturalize as appropriate

Recommended Languages

English, French, Italian, German, Spanish

Japanese, Korean, Traditional Chinese, Simplified Chinese

Brazilian Portuguese, Russian, Turkish, Arabic



developer.apple.com/internationalization

1. Remove Friction
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5. Foster Engagement
6. Use Background Transfers
7. Optimize Graphics Performance
8. Make a Great Preview Video
9. Localize

Target the State of the Art

State of the Art

Take advantage of the latest iOS devices

State of the Art

Take advantage of the latest iOS devices

Target the latest iOS release

State of the Art

Take advantage of the latest iOS devices

Target the latest iOS release

Provide fallbacks for iOS 7

8

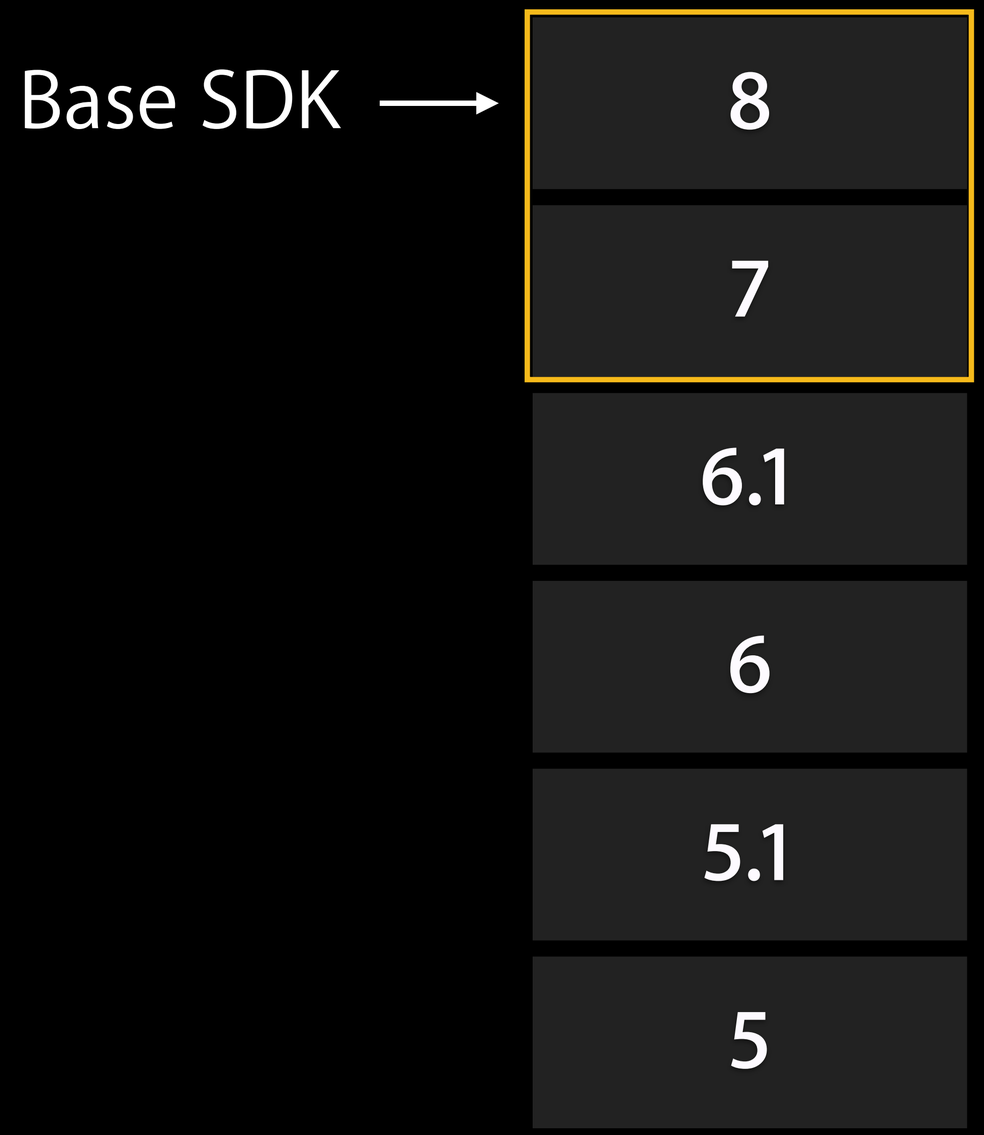
7

6.1

6

5.1

5


Base SDK
8
7
6.1
6
5.1
5

Base SDK
8
7
Deployment Target
6.1
6
5.1
5

State of the Art

Take advantage of the latest iOS devices

Target the latest iOS release

Provide fallbacks for iOS 7

Integrate with built-in game technologies

SpriteKit

Metal

SceneKit

Game Center

OpenGL ES 3.0

Game Controllers

Design
News
ART
TRAVEL
SPORTS
280
A7
M7

1. Remove Friction
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4. Design for Touch
5. Foster Engagement
6. Use Background Transfers
7. Optimize Graphics Performance
8. Make a Great Preview Video
9. Localize
10. Target the State of the Art

Go to Eleven

1
6
8
0
11
GAIN
VOLUME
TREBLE

1. Remove Friction
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5. Foster Engagement
6. Use Background Transfers
7. Optimize Graphics Performance
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11. Go to Eleven

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9. Localize
10. Target the State of the Art
11. Go to Eleven

Wrap-Up

Geoff Stahl
Director, Games and Graphics Software

Apple Design Award 2014
Honoring Outstanding Design and Innovation

Get Together

• Game Developer Get Together	Broadway	Thursday 4:30PM

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http://devforums.apple.com

WWDC14