



Google
Developers



#io12

YouTube API + Cloud Rendering = Happy Mobile Gamers

Daniel Hermes, Jarek Wilkiewicz & Kenji Arai (Google/YouTube)

Jens Owen (LunarG), Wayne Karo (Free Range Games)

Amir Ebrahimi (Luminary Productions)

Coby Cotton (Dude Perfect)

v00.14



Agenda



[YOUTUBE.COM/DEV](https://www.youtube.com/dev)

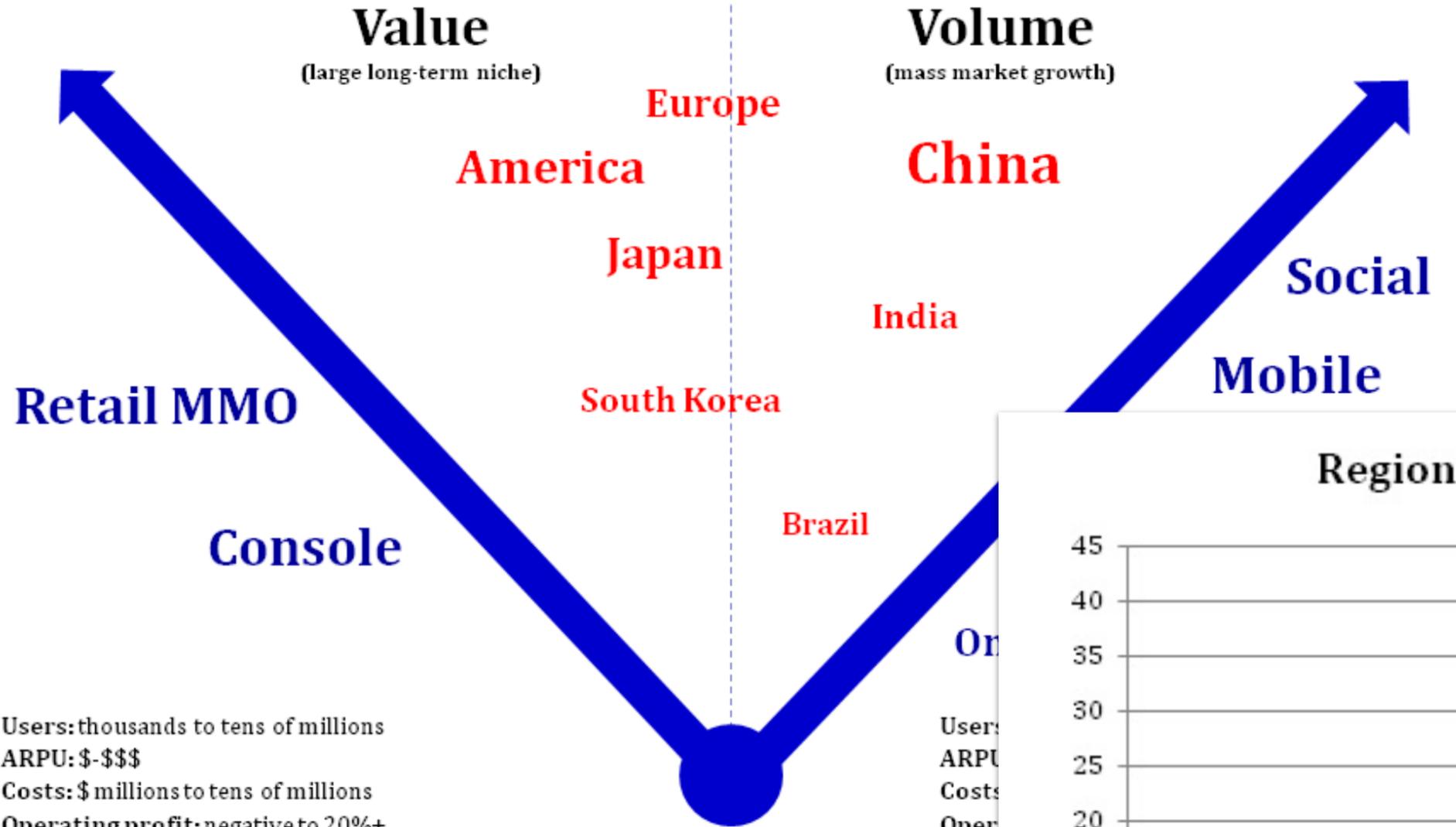




Mobile Gaming & Video

Trends

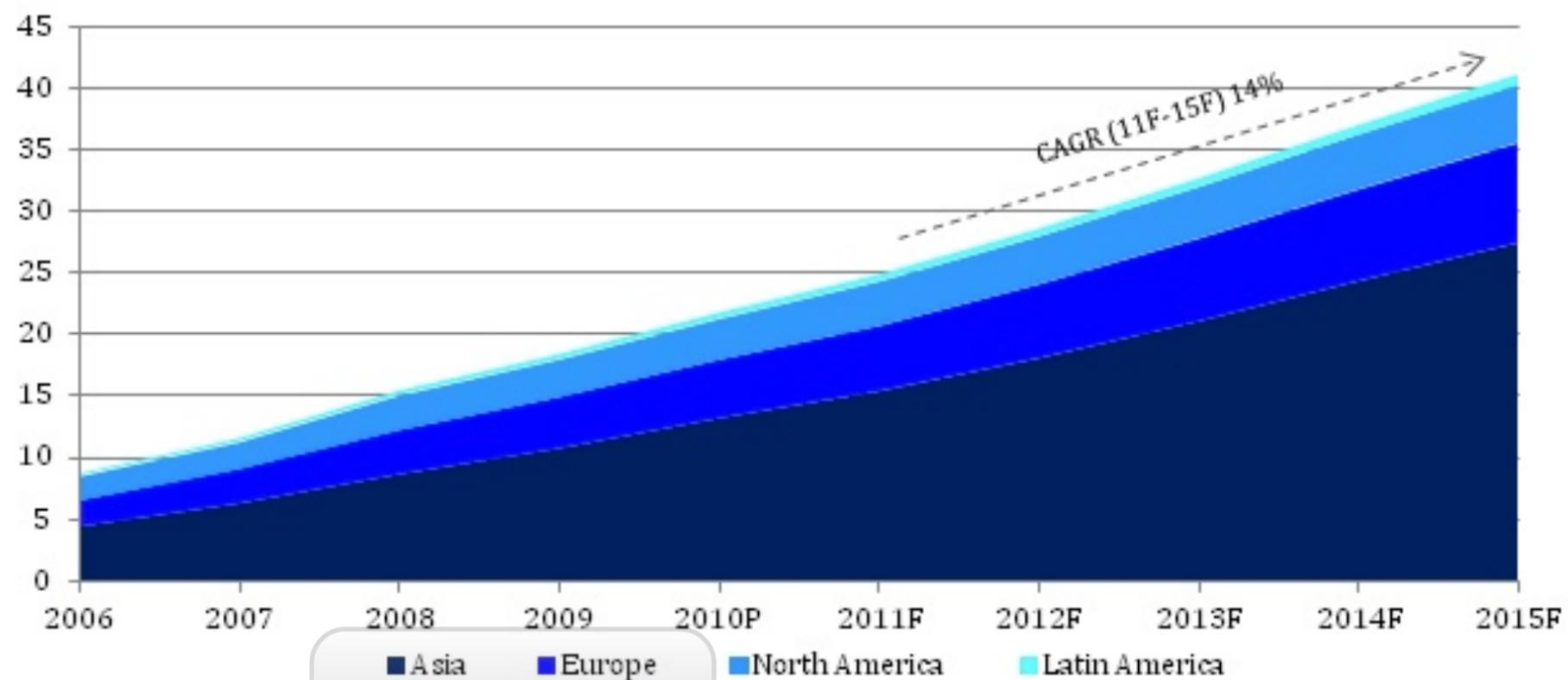
The Big V: the great games market split



Users: thousands to tens of millions
 ARPU: \$-\$\$\$
 Costs: \$ millions to tens of millions
 Operating profit: negative to 20%+
 Growth rates: negative to <10%
 Business model: unit sales, subscriptions, virtual goods

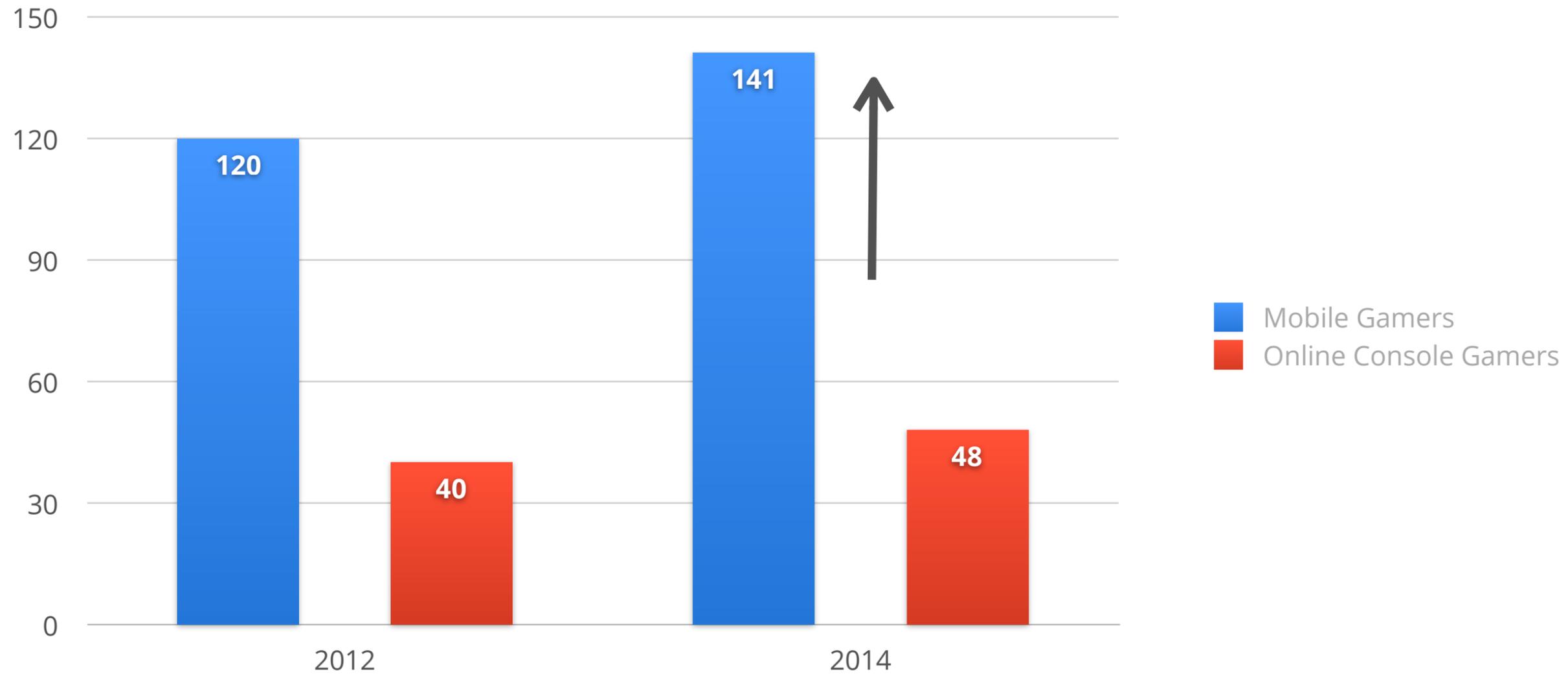


Regional Online/Mobile Games Revenue (\$B)



Mobile Gaming Growth

United States (Millions)



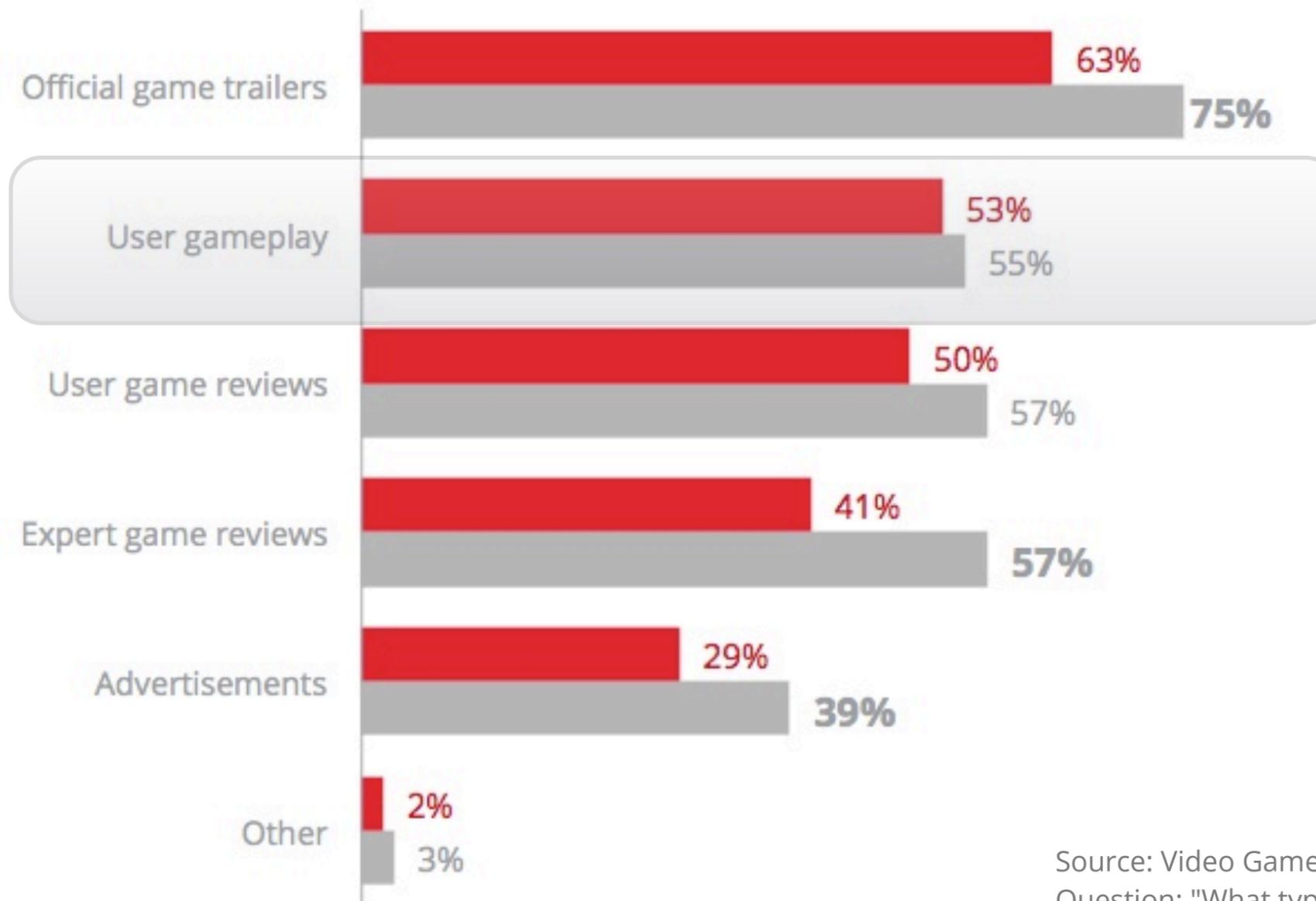
source: eMarketer, Feb&March 2012

Note: gaming audiences not mutually exclusive, there is overlap between groups



Gamers Love Gameplay Videos

Preferred Types of Online Video



Casual Gamers

Core Gamers

Source: Video Game Purchase Behavior Research, Ipsos OTX, 2012.
Question: "What type of gaming-related video do gamers prefer to watch?"





You Tube

Quiz

- 200 million

- Number of daily mobile YouTube views in 2010

- 600 million

- Number of daily mobile YouTube views in 2012

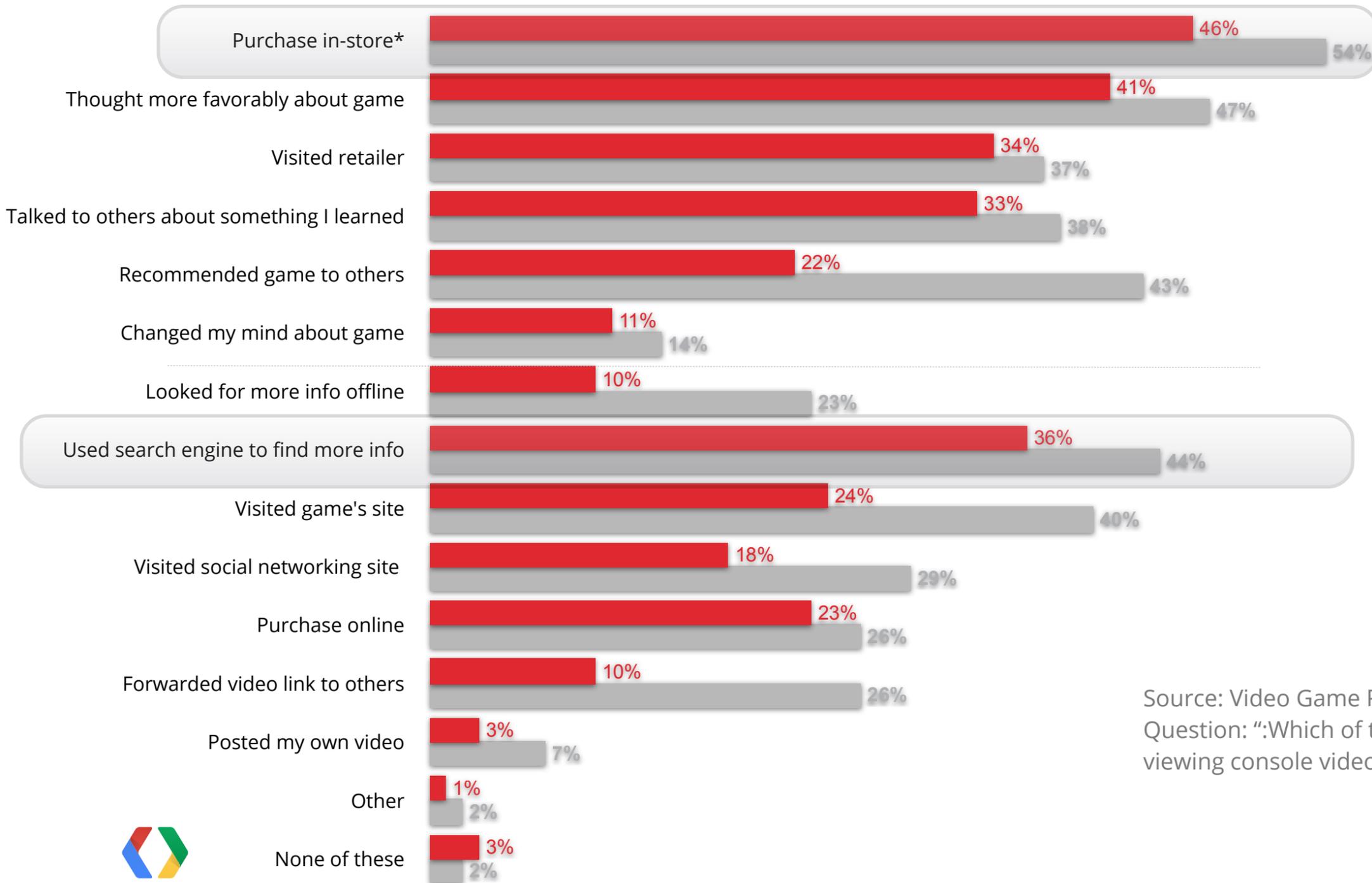
- 800 million

- YouTube users worldwide



Video viewing drives online + offline behavior

Actions Taken After Viewing Online Video



Casual Gamers
64% made a **purchase***
82% took **offline** action
66% took **online** action

Core Gamers
72% made a **purchase***
89% took **offline** action
76% took **online** action

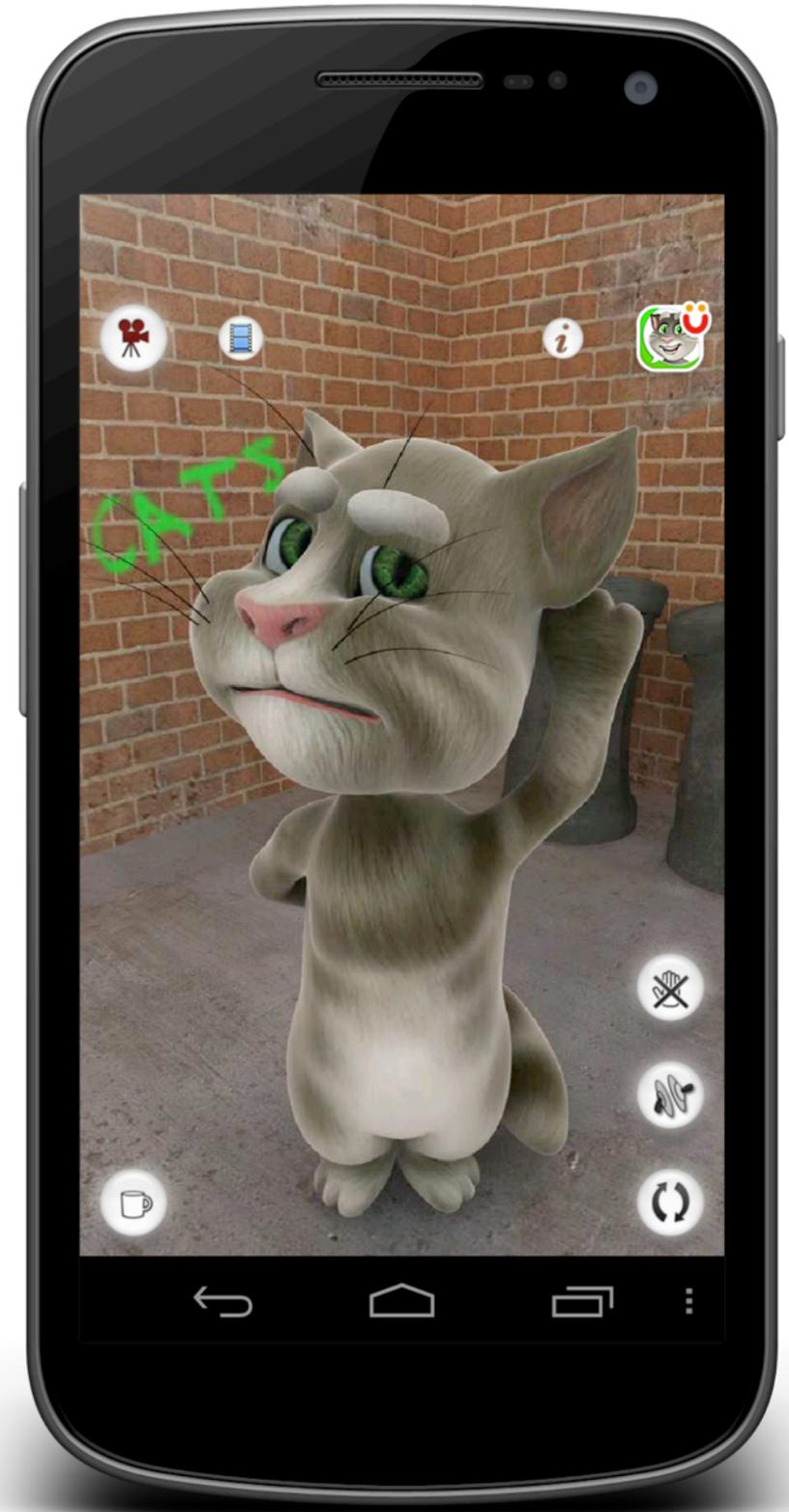
Source: Video Game Purchase Behavior Research, Ipsos OTX, 2012
 Question: "Which of the following actions, if any, did you take as a result of viewing console video games related videos online? (Select all that apply) "



Talking Tom

Outfit7

- Over 400M app downloads to date
- Over 115M monthly active users
- Total video uploads: >750K
- Total views: >345M views
- Emphasis on self expression & story telling



What if I Do Nothing?

Things You Will Miss Out On

- User engagement
- Community building
- Viral promotion
- Analytics
- Catching the mobile gaming wave
- Monetization



Source: <http://www.flickr.com/photos/kristianderic/61634095/sizes/z/in/photostream/>



Is it Hard?



Source: photo by kalidoskopika <http://www.flickr.com/photos/kalidoskopika/2022600793/sizes/l/in/photostream/>





YouTube APIs

A Refresher

YouTube API Overview



Data APIs



Player APIs

YouTube API Overview

- Data API
 - RESTful
 - Resumable **Uploads**
 - Standard feeds (Top Rated, Most Viewed, etc.)
 - User's playlists, subscriptions, uploads feeds
 - User's comments, profile
 - Example <http://goo.gl/TEMZm>
- Player API
 - Control the player behavior
 - JavaScript, ActionScript, player parameters
 - **New** Android Player API (check out our [session](#) tomorrow)





Capturing Mobile Video

Challenges and Solutions





BMW i8 Concept



Photo by mariordo59, source: <http://www.flickr.com/photos/30998987@N03/5270021907/sizes/l/in/photostream/>

Mobile Video Capture Design Choices

One Size Does Not Fit All

Local

On-device
Capture
Encode
Upload



Cloud

Capture State
Render, Encode in
the Cloud



Hybrid

Capture Graphics
Subsystem Calls
Render and Encode
in the Cloud





Local Capture

On-Device Video Rendering and Encoding



FOX & friends

LIVE
FOX NEWS
radio

NL MIL 4 STL 5



Coby Cotton



Who is Dude Perfect?

Formed early 2009

5 Competitive college roommates

Trick Shot Entertainers

Go Big approach to life

250K YouTube subscribers

80 MILLION worldwide views



DUDE PERFECT



Television Appearances Include...



Kimmel, CBS Early Show & Evening News, ESPY's Red Carpet, Good Morning America, Regis and Kelly, ESPN's E:60, SportsNation, Fox and Friends & Many More



DUDE PERFECT



Ad Age Ranks DP in Top 10

AdvertisingAge®

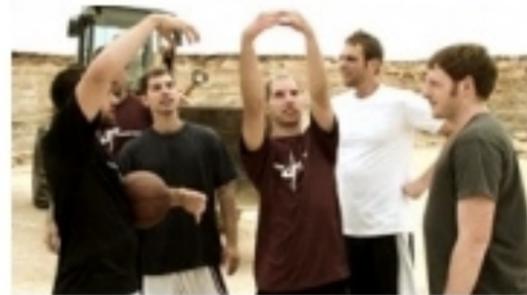
Meet YouTube's Most In-Demand Brand Stars

For Marketers, Web-Video Celebrities Offer Trusted Voices and an Engaged Viewership

by [Irina Slutsky](#)

Published: [September 13, 2010](#)

DUDEPERFECT



dudeperfect

WHO ARE THEY? Garrett Hilbert, Cory Cotton, Cody Jones, Sean Townsend, Panda, Coby Cotton, and Tyler Toney -- a team of [trick-shot basketball entertainers](#) from Texas

CONTENT: Impossible basketball shots

VIEWS (ALL-TIME): 27,712,318

BRAND VIDEO VIEWS: 3,241,856 (top campaign for GMC snagged 1,917,028 views)



DUDE PERFECT

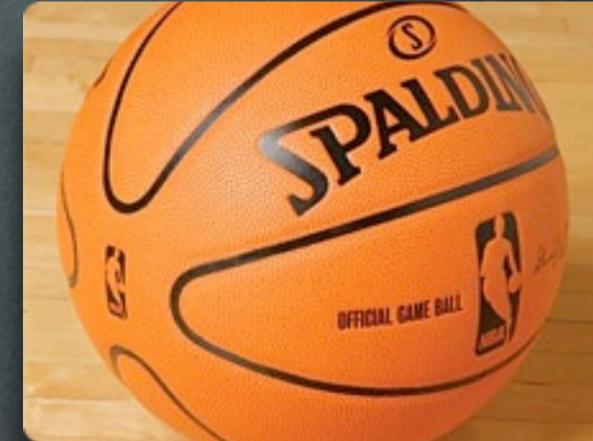
* AdAge.com - September 2010



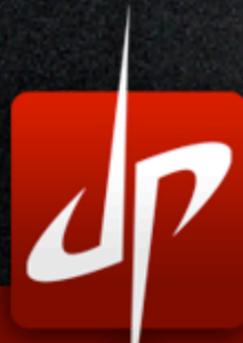
Brands On Board with Dude Perfect



at&t



GOODYEAR.



DUDE PERFECT



The Game



#1 Sports Game on Android & iPhone
Approaching 1 Million Downloads



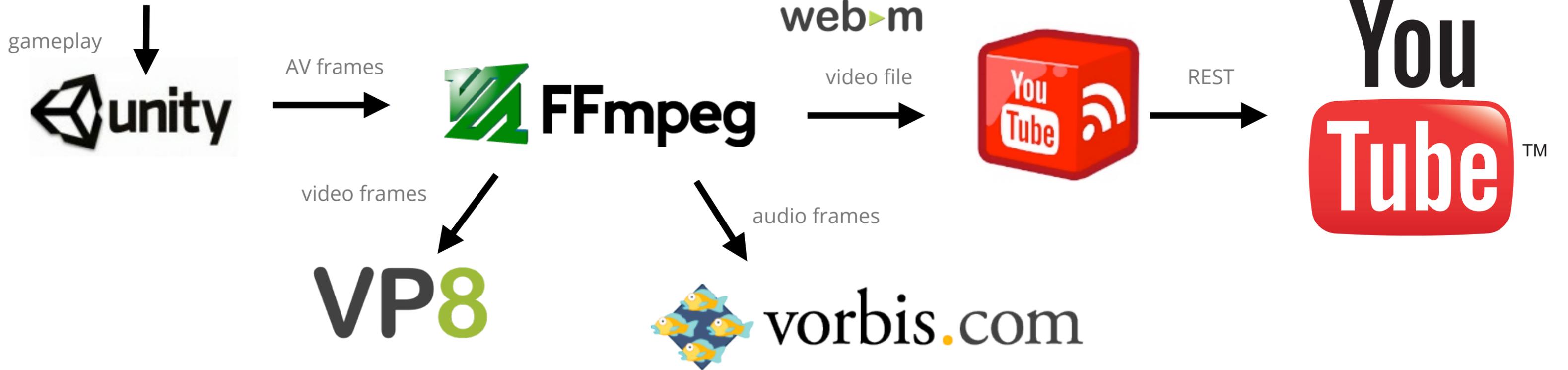
DUDE PERFECT

Demo



How it Works

Dude Perfect Local Capture Design



Audio and Video Capture

Unity AV Capture



```
public static function VCR_Run()  
{  
    fPlaybackStartTime = Time.time;  
    for (var camera in Camera.allCameras)  
    {  
        var ffmpeg = camera.GetComponent(FFMpeg);  
        if (ffmpeg)  
        {  
            if (ffmpeg.hasAudio)  
                ffmpeg.RecordVideo();  
            else  
                ffmpeg.RecordAudio();  
            break;  
        }  
    }  
}
```

JavaScript

```
public class FFMpeg : MonoBehaviour {  
    public void RecordVideo()  
        StartCoroutine(CaptureVideo());  
}  
IEnumerator CaptureVideo()  
{  
    [...]  
    while (recordingVideo)  
    {  
        yield return new WaitForEndOfFrame();  
        if (framesRendered >= rt.Length)  
        {  
            int rtIndex = framesEncoded % rt.Length;  
            RenderTexture.active = rt[rtIndex];  
            ffmpeg_encodeVideoFrame();  
            [...]  
        }  
    }  
}
```

C#



Audio and Video Encoding

WebM and FFmpeg (VP8+Vorbis)



```
public class FFMpeg : MonoBehaviour
{
    [DllImport("ffmpeg")]
    private static extern int ffmpeg_init(int width, int height, int video_frame_rate, int audio_sample_rate,
                                         int audio_channels, string url);

    [DllImport("ffmpeg")]
    private static extern void ffmpeg_shutdown();

    // buffer is read in native code
    [DllImport("ffmpeg")]
    private static extern void ffmpeg_encodeVideoFrame();

    [DllImport("ffmpeg")]
    private static extern void ffmpeg_encodeAudioFrame(IntPtr samples, int samples_length);
    [...]
}
```

C#



Audio and Video Encoding



Init

```
int ffmpeg_init(int width, int height, int video_frame_rate, int audio_sample_rate, int audio_channels,
               const char* url)
{
    /* initialize libavcodec, and register all codecs and formats */
    av_register_all();
    av_log_set_callback(log_callback);
    /* auto detect the output format from the name (.webm) */
    AVOutputFormat *fmt = av_guess_format(NULL, url, NULL);
    /* allocate the output media context */
    AVFormatContext* oc = s_fmt_context = avformat_alloc_context();
    oc->oformat = fmt;
    /* add the audio and video streams using the default format codecs and initialize the codecs */
    video_st = s_video_stream = add_video_stream(oc, fmt->video_codec, width, height, video_frame_rate);
    audio_st = s_audio_stream = add_audio_stream(oc, fmt->audio_codec, audio_sample_rate, audio_channels);
    [...]
    /* open codecs */
    open_video(oc, video_st);
    open_audio(oc, audio_st, audio_sample_rate);
}
```

C



Video Encoding

Frame Processing

VP8

```
void ffmpeg_encodeVideoFrame() {
    [ ... ]
    glReadPixels(0, 0, c->width, c->height, GL_RGBA, GL_UNSIGNED_BYTE, s_rgba_data);
    write_video_frame(s_fmt_context, s_video_stream, s_rgba_data);
}
static void write_video_frame(AVFormatContext *oc, AVStream *st, uint8_t* rgba_data) {
    // However, we need to flip our image, since GL returns it upside down
    avpicture_fill((AVPicture*)tmp_picture, (uint8_t*)(rgba_data + c->width * 4 * (c-> height - 1)),
        PIX_FMT_RGBA, c->width, c->height);
    for (int i = 0; i < 4; i++)
        tmp_picture->linesize[i] = -tmp_picture->linesize[i];
    sws_scale(img_convert_ctx, (const uint8_t* const*)tmp_picture->data, tmp_picture->linesize,
        0, c->height, picture->data, picture->linesize); [ ... ]
    out_size = avcodec_encode_video(c, video_outbuf, video_outbuf_size, pkt_picture); [ ... ]
    if (c->coded_frame->pts != AV_NOPTS_VALUE)
        pkt.pts= av_rescale_q(c->coded_frame->pts, c->time_base, st->time_base); [ ... ]
    ret = av_interleaved_write_frame(oc, &pkt);
}
```

C



Audio Encoding

Presentation Time Stamp (PTS) Processing



vorbis.com

C

```
void ffmpeg_encodeAudioFrame(short* samples, int samples_length)
{
    [ ... ]
    AudioBuffer_Push(samples, samples_length * c->channels);
    int samples_written = 0;
    while (AudioBuffer_Size() / c->channels >= c->frame_size)
    {
        write_audio_frame(s_fmt_context, s_audio_stream, AudioBuffer_Get());
        AudioBuffer_Pop(c->frame_size * c->channels);
    }
}

static void write_audio_frame(AVFormatContext *oc, AVStream *st, short* samples)
{
    [ ... ]
    pkt.size= avcodec_encode_audio(c, audio_outbuf, audio_outbuf_size, samples);
    if (c->coded_frame && c->coded_frame->pts != AV_NOPTS_VALUE)
        pkt.pts= av_rescale_q(c->coded_frame->pts, c->time_base, st->time_base); [ ... ]
    if (av_interleaved_write_frame(oc, &pkt) != 0) [...]
}
}
```



Upload

YouTube API



HTTP

```
POST /resumable/feeds/api/users/default/uploads HTTP/1.1
```

```
Host: uploads.gdata.youtube.com
```

```
Authorization: Bearer ACCESS_TOKEN
```

```
GData-Version: 2
```

```
X-GData-Key: key=adf15ee97731bca89da876c...a8dc
```

```
Content-Length: 1941255
```

```
Slug: my_file.webm
```

```
Content-Type: application/atom+xml; charset=UTF-8
```

```
<?xml version="1.0"?>
```

```
<entry xmlns="http://www.w3.org/2005/Atom"  
  xmlns:media="http://search.yahoo.com/mrss/"  
  xmlns:yt="http://gdata.youtube.com/schemas/2007">
```

```
  <media:group>
```

```
    <media:title type="plain">My Awesome Shot</media:title>
```

```
    <media:description type="plain">http://game.dudeperfect.com/ Best shot ever!</media:description>
```

```
    <media:category
```

```
      scheme="http://gdata.youtube.com/schemas/2007/categories.cat">Gaming</media:category>
```

```
    <media:keywords>"Dude Perfect" hoops basketball</media:keywords>
```

```
  </media:group>
```

```
</entry>
```





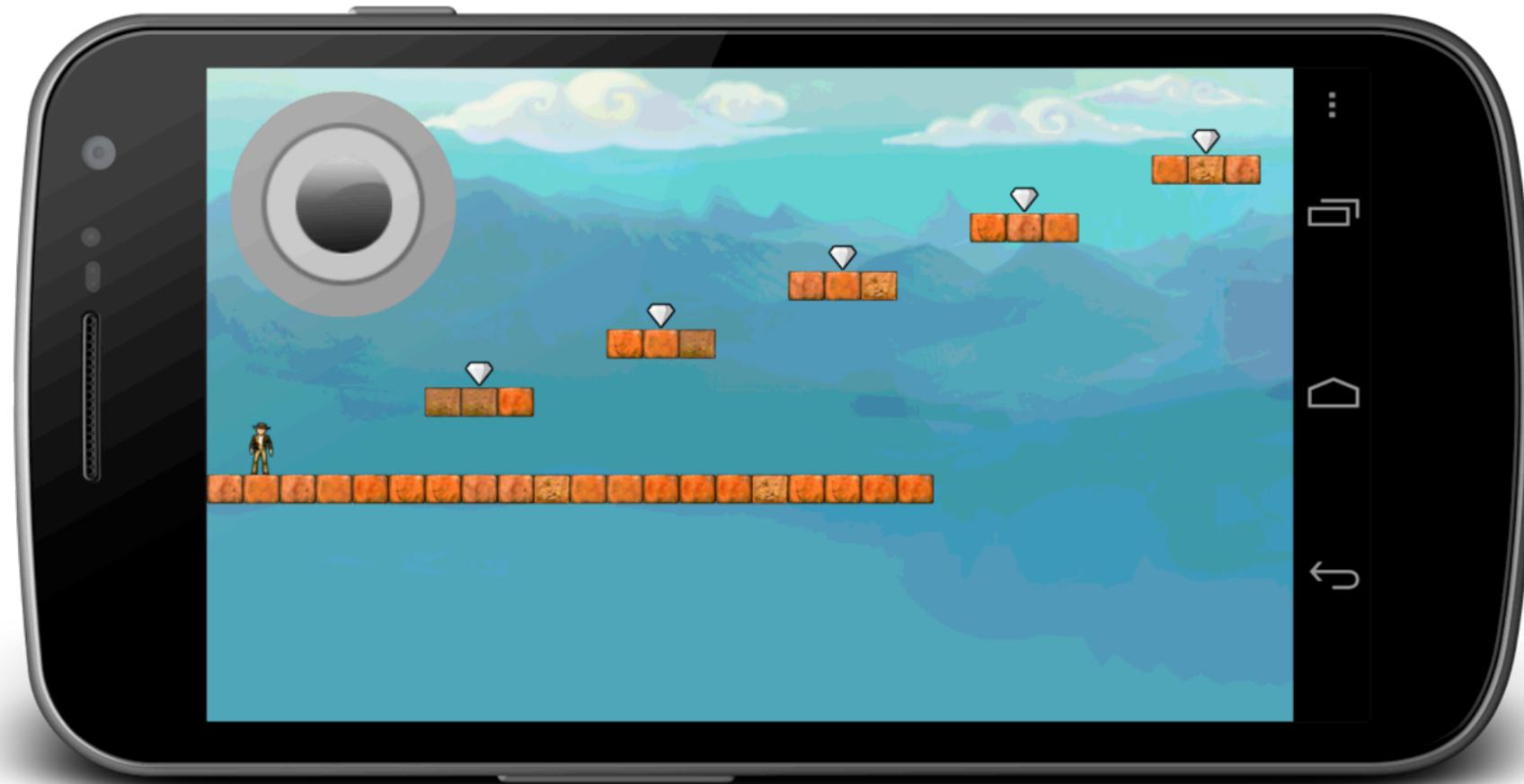


Cloud Approach

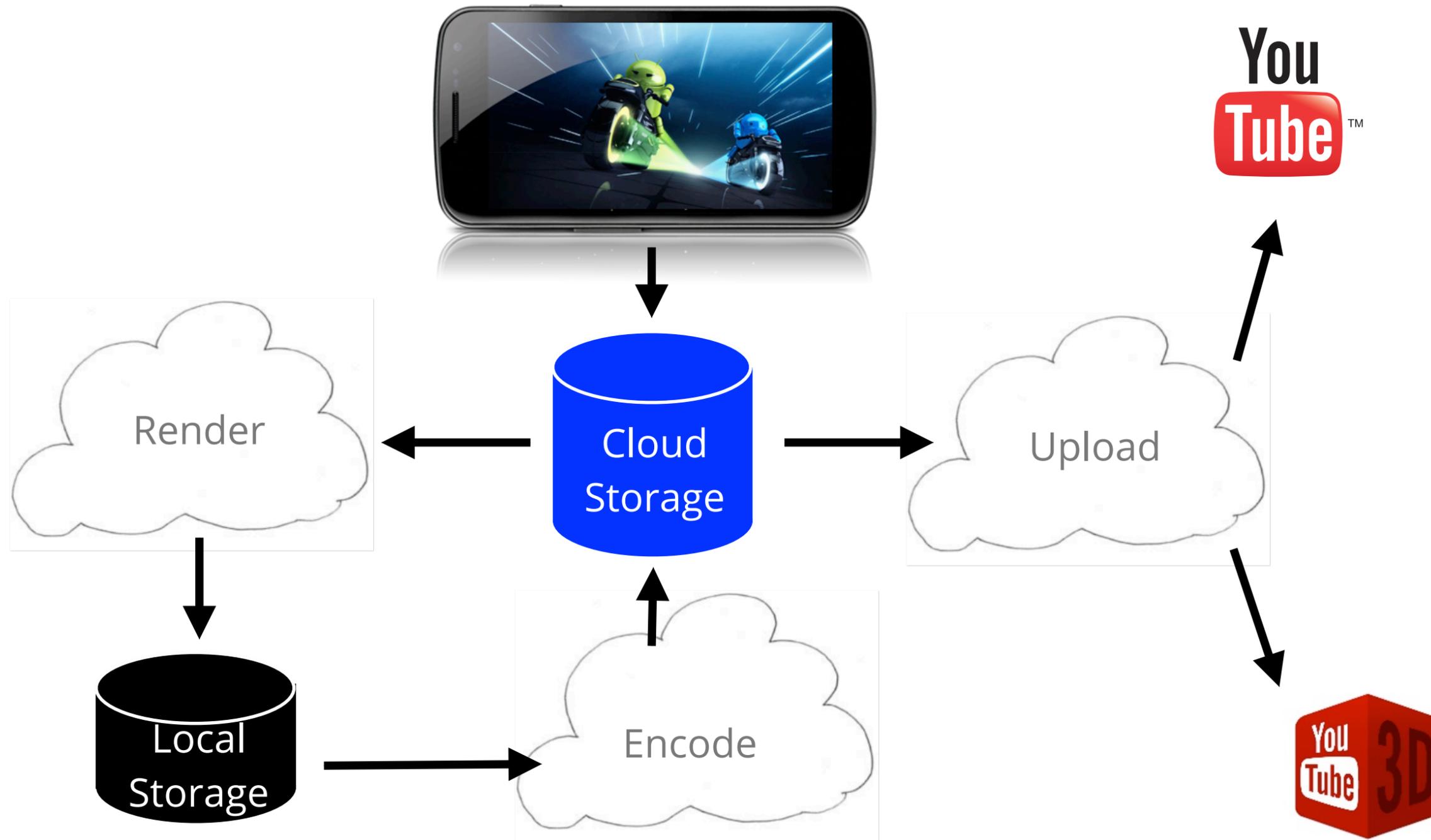
Proof of Concept



Proof of Concept: Platformer Demo



System Overview

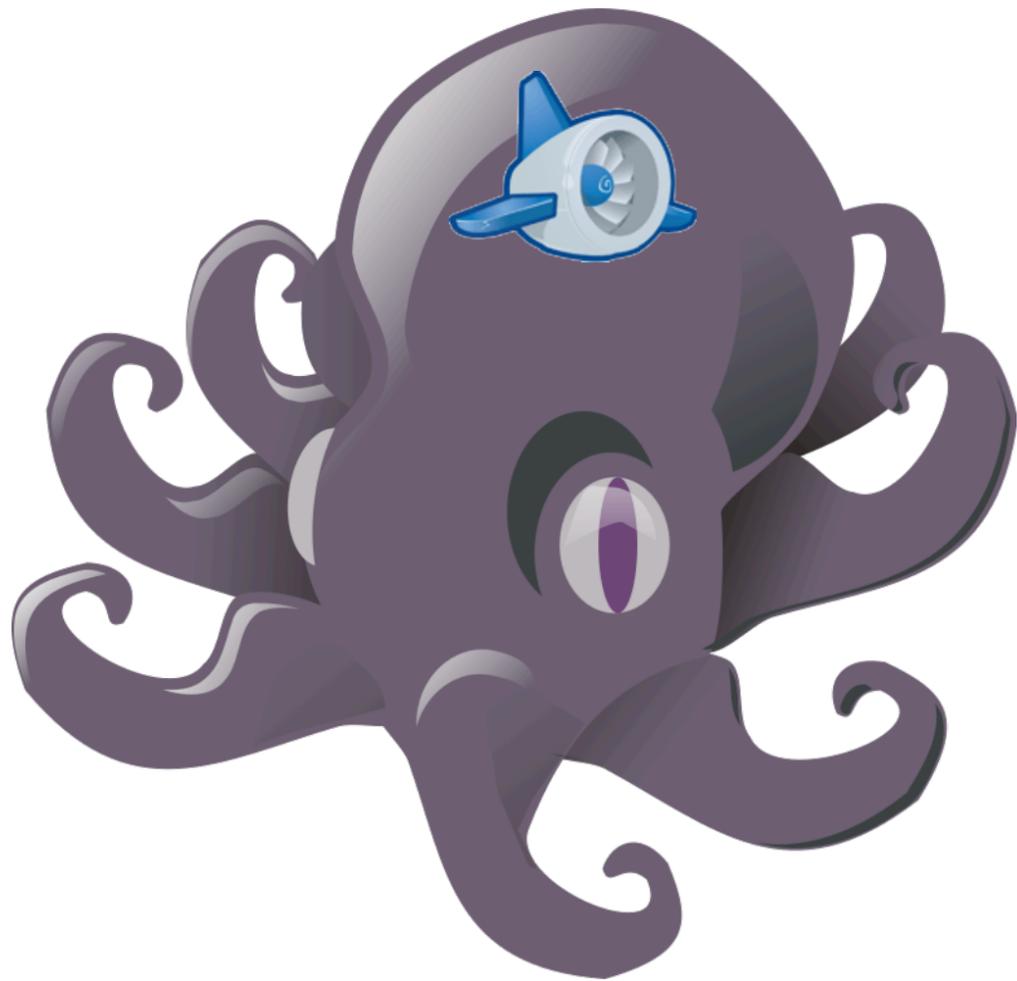


Cloud Rendering Requirements

- Linux machine(s) for rendering
- Storage mechanism
- Controller with very reliable uptime
- Decoupling of components



Controller: Google App Engine

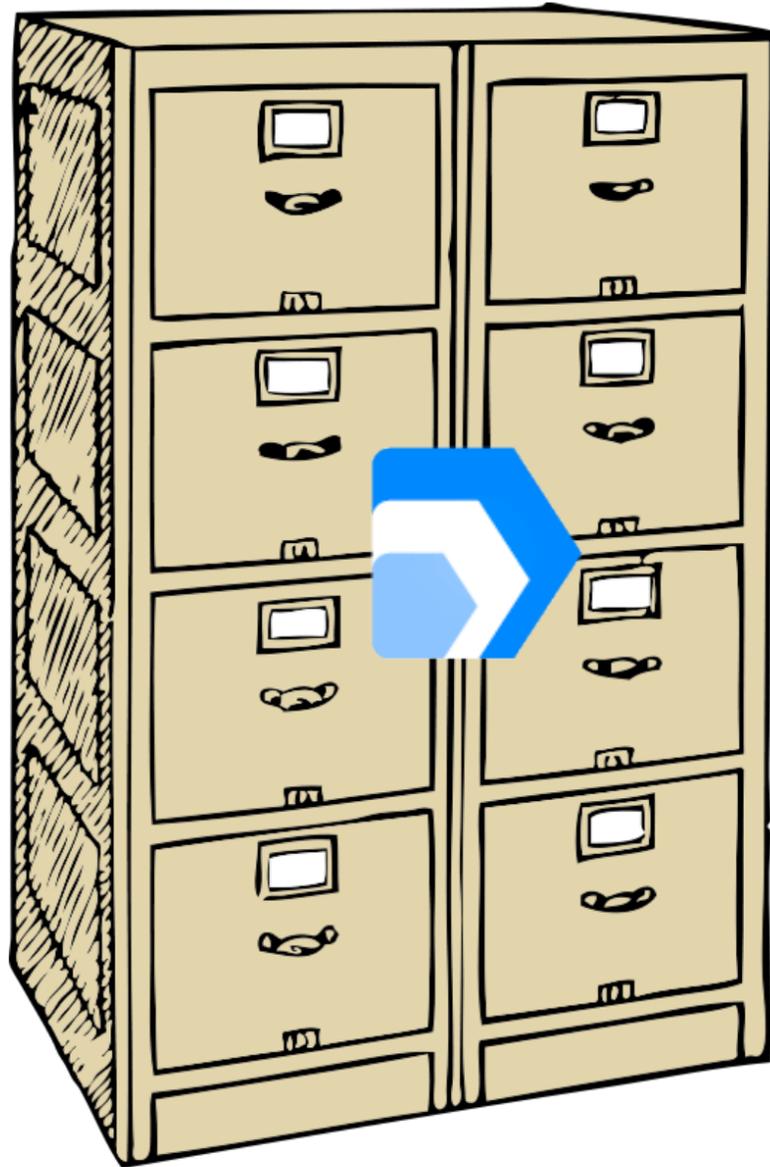


- URL Listeners
- Task Queues
- Control and Communicate with Linux Machines
- C2DM (Cloud to Device Messaging) framework

source: openclipart.org/detail/20079/little-octopus-by-rg1024



Storage: Google Cloud Storage



- Filesystem like integration with GAE
- Open Source CLI tool Source at: code.google.com/p/gsutil/
- Seamless video upload:
`gsutil cp video_file.webm gs://videos`
- Bonus: Post-upload hooks!

source: openclipart.org/detail/16266/multiple-files-by-johnny_automatic-16266



Renderer: Set of Headless Linux Machines



- Runs native code: e.g. `ffmpeg`
- Scalable processing resources
- Sends video to storage

Source: [flickr.com/photos/jasoncross/638462445/](https://www.flickr.com/photos/jasoncross/638462445/)





Tying It All Together

Collecting and Sending Gameplay Data



```
public class ReplayStore {  
    ...  
    public void incrementFrame() {  
        if (!isReplay()) {  
            if (!currFrameEvents.equals(prevFrameEvents)) {  
                setFrameEvents(currFrameEvents);  
                prevFrameEvents = currFrameEvents;  
            }  
        }  
        currFrame++;  
        currFrameEvents = new TreeSet<Integer>();  
    }  
    ...  
}
```

JAVA



Replay Processing Hooks



JAVA

```
public void update(float delta) {  
    ...  
    if (replayStore.isReplay()) {  
        keyboard.setKeyDown(replayStore.getKeyEvents());  
    }  
    ...  
    level.Update(delta / 1000, keyboardState, ...  
    replayStore.incrementFrame();  
    ...  
}
```



Rendering Overview

- Available Linux Machines poll for jobs from controller
- Retrieve Gameplay data
`gsutil cp gs://videos/gameplay_data.json .`
- Use PlayN binary to replay and capture game
- Encode Captured Data:
 - Stitch frames with `ffmpeg`
 - Combine sound assets with `sox`
- Upload Encoded Video to YouTube





Implementation Challenges

Challenges and Considerations



- UX Intrusion
- Inconsistent state
- Sound is hard
- Engine/platform specific

source: statusoftheboulder.com/meatus/images/sisyphus2.jpg





Payoff

Platformer Gameplay Video

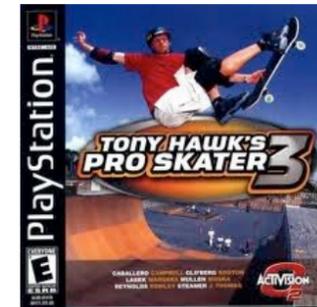




FreeRange
Games

About Free Range Games

- Free Range Games was founded in 2009
- Core team has worked together for over a decade
- Developing console quality games for web and mobile devices
- Small, senior teams
- Unity 3D engine
- Past console experience includes:



FreeFall Tournament

- Space marines
- 3rd person shooter
- 8-on-8 matches

- Free-to-play
- Browser game on Kongregate.com

Instructions Rate: ★★★★★ Favorited Get Kreds! Like 810 Tweet 28 (freerangegames)

FREEFALL TOURNAMENT

PLAY NOW

0:33 / 1:04

LATEST NEWS

UPDATES IN PROGRESS
Let your voice be heard! Send bugs and feedback to:
freefall@freerangegames.com

GAMER'S GAME
Freefall Tournament is best enjoyed with:

- 2-Button mouse
- Ethernet (plug-in) connection

WEAPONS UPDATE COMING SOON
Read our post in the Forums for more information!

GUNNER TECH TANK SCOUT

CHAT GAME HIGH SCORES

Room: Freefall Tournament - Room #01 (137)

Room	Game	Chat actions
freerangegames	8 D	
abraaz	42 D	
Clev1	15	
Glock243	22	
Major007	2	
ooddrraa	2	

sammymon: no ones in dock2
Glock243: I'm at 2500 right now
Glock243: Should be 3000 tomorrow
tylerrocket5: For me theres eight people in here.
tylerrocket5: Glock when did this happen? O.O
abraaz: I'm on 964 xD
abraaz: Whats your cash?
tylerrocket5: Mine?
abraaz: Sure, but it was aimed at glock.
tylerrocket5: I have 1340. He said 2500 earlier.
Glock243: 28485
tylerrocket5: Ohdamn.
abraaz: Nice.
Glock243: Should be 30k by end of today
t0pDr0p: hey
abraaz: 13.2K here.
abraaz: Enough for 1-2 weps I hope.
abraaz: Do you know of a definitive price range?
Glock243: Hope they cost 10k
tylerrocket5: abraaz, wouldn't you be one of the first people to know?

FreeFall Horizon

- Familiar Sci-Fi space theme
- Awesome space ships
- Missiles and explosions
- Endless run game
- Casual controls
- Twitter and Facebook integration
- Devices: iOS & Android



SummitX Snowboarding

- Mobile Extreme Sports
- Majestic HD 3D terrain
- True-to-sport physics
- Multi-branching runs

- Publisher is Com2uS
- Devices: iOS & Android
- Dec 15, 2011 commercial release



Rendering Mobile Gameplay on YouTube

- Share with Friends
 - Show off awesome moments
- Leaderboards
 - See how good the leaders are
 - Show off how good you are
- Discovery
 - Leverage YouTube as a viral channel
- Monetization
 - Ad revenue to support maintenance



Mobile Development Best Practices

- **Avoid performance hits**
 - Selective use of shaders and transparency
 - Bundle art assets
 - Balance background processing, e.g. gameplay video rendering for YouTube
- **Continuously test on device**
 - Make sure frame rate does not drop
- **Flexible UI system**
 - Handle lots of different dimensions
 - Heterogeneous device mix
- **Hardware improves rapidly**
 - Opening new possibilities for innovation, e.g. gameplay video rendering for YouTube
 - and hence discovery





SeeMeGaming.com

Hybrid Approach



3D Driver Guys' Perspective

LunarG has deep experience developing 3D Drivers



High Performance for Workstations

Low Cost for Laptops and Desktop

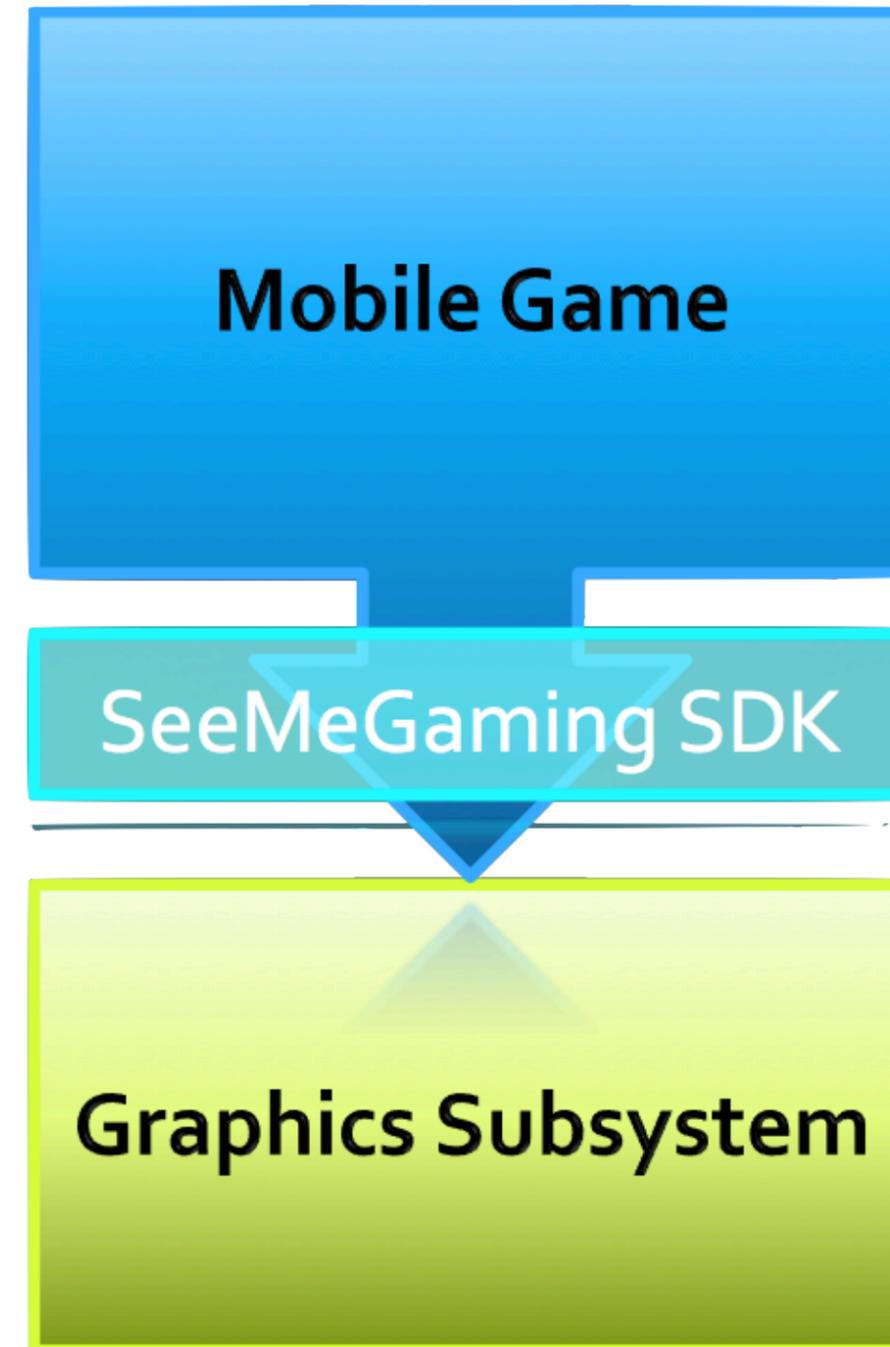
Low Power for Phones and Tablets

We applied that experience to SeeMeGaming...



A Novel Approach

SeeMeGaming captures
the **3D** command stream
BEFORE
sending it to the
Graphics Processor



Use The SeeMeGaming Approach to

Capture During Game Play

No replay capability required

MUCH faster than reading back pixels

Achieve Easy In-Game Integration

SDK includes YouTube and
Social Authentication

Offload Video Conversion to the Cloud

Saving time and battery on the device



SummitX Demo

Live Game Play Capture

10 second clip marked in-run
Replay or share at end of run



Modified Unity Engine

Enabled 3D Command Stream to be Captured Live

Offload Video Conversion to the Cloud

Saving time and battery on the device



Unity Source-Level Integration

Proof of Concept



```
[ ... ]  
// Configure Unity (UnityPrefix.h)  
#include "Configuration/PrefixConfigure.h"  
  
#if UNITY_ANDROID  
#include "apitrace.h" // ← SMG header redirection  
#endif  
  
#ifdef __cplusplus  
  
// STD  
#include <algorithm>  
#include <cmath>  
#include <vector>  
#include <deque>  
#include <map>  
[ ... ]
```

```
JNI_METHOD_DECL (void, unityAndroidInit, JNIEnv*  
jobject this, jstring appPath, jstring libPath)  
{ [ ... ]  
    if (!m_Initialized)  
    {  
        const char *err;  
        err = apitraceStartToFile("/sdcard/smg_test.trace");  
        if (!err)  
            err = apitraceFakeEGLInit();  
        [ ... ]  
        UnityInitApplication (app_path, lib_path);  
    }  
}  
JNI_METHOD_DECL (bool, nativePause, JNIEnv* env, jobject  
this)  
{  
    bool result = UnityPause(1);  
    apiTraceStop();  
    return result;  
}
```



2 Simple Code Changes to Integrate SeeMeGaming

1) Mark points of interest and how many seconds to go back in time

```
SMGMarkRecording(10.0);
```

2) When level is complete, enable Users to Share Game Play Videos

```
SMGShareRecording("/SDCARD/...",  
"http://freerangegames.com/summitx Best Trick on Angels Peak!");
```



SeeMeGaming vs Pixel Readback

3D Capture is much lighter than Pixel Readback

	Size	Perf Impact
3D Command Stream		
Raw Data	186MB	Light
Compressed to SDCARD	142MB	Deferred
Video Encode	2.5MB	Deferred
Pixel Readback		
Raw Data	>3GB	Heavy
Compressed to SDCARD	>190MB	Heavy
Video Encode	2.5MB	Heavy



300

1:54

15 fps

78 mph



+0:03



Summary

YouTube API in Your Next Title



+



=



[YOUTUBE.COM/DEV](https://www.youtube.com/dev)





Q&A

#io12

goo.gl/sessionfeedback

<Thank You!>

youtube.com/dev

@YouTubeDev

[G+: YouTube For Developers](#)

[G+: profiles.google.com/jarek.wilkiewicz](https://profiles.google.com/jarek.wilkiewicz)

[G+: profiles.google.com/daniel.j.hermes](https://profiles.google.com/daniel.j.hermes)



#io12

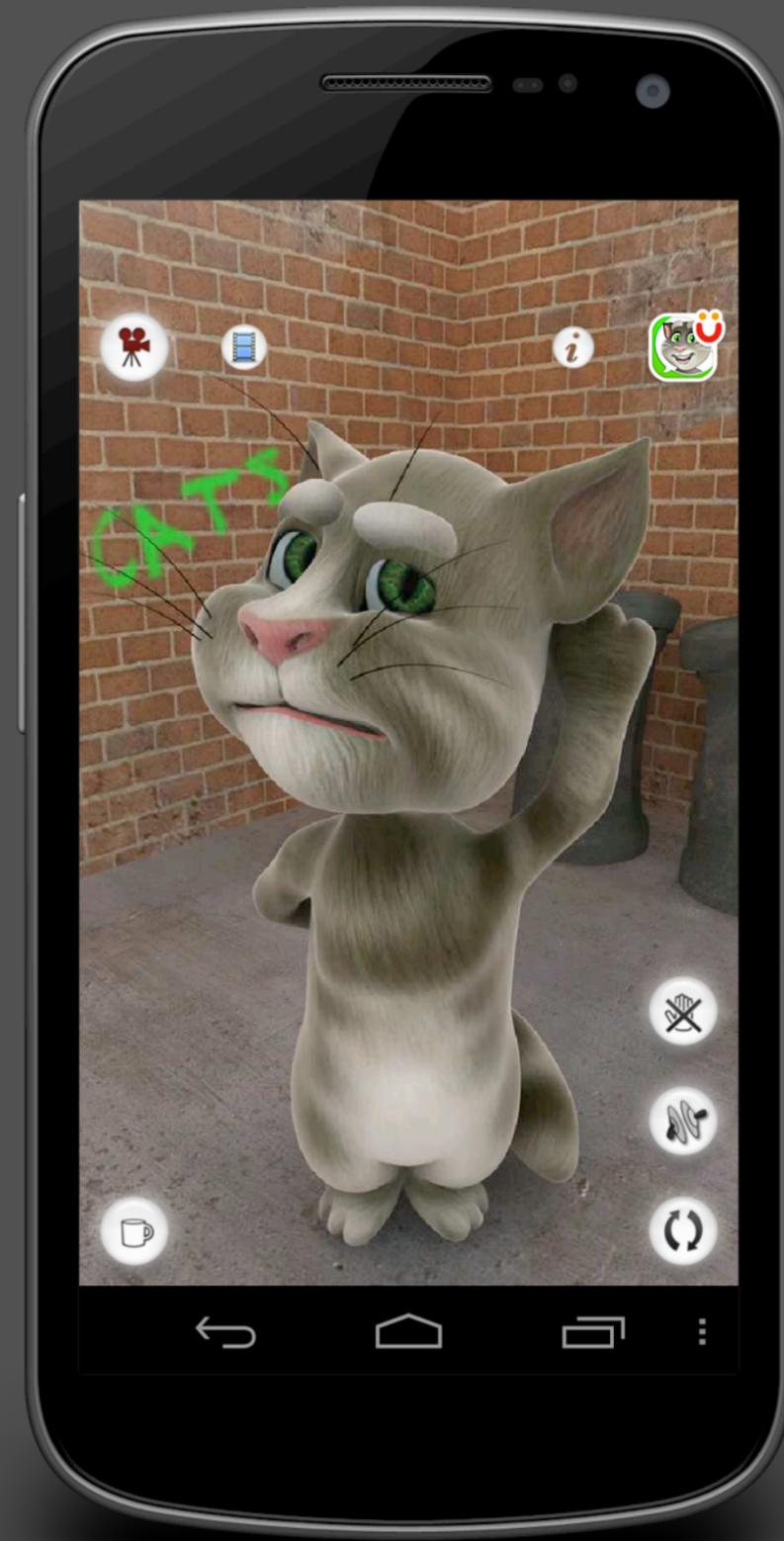
goo.gl/sessionfeedback



Backup Slides



Talking Tom



Local Capture Example

Talking Tom

Global reach

>400 million
Total app downloads, with
almost half our users in Asia

120
Countries

115+ million
Monthly active users

30+ million
New monthly app downloads

10,6,3 Months
to reach every new 100
million users downloads

Loyal engaged users

31% and 20%
Share of users downloading
2 or 3 characters/apps and
downloading 4 or more
characters/apps

73%
Share of users likely to
recommend app to friends
(Net Promoter Score)

Rich data

>1 terabyte
Of data collected every
week (U.S. library
of congress every
3 months)

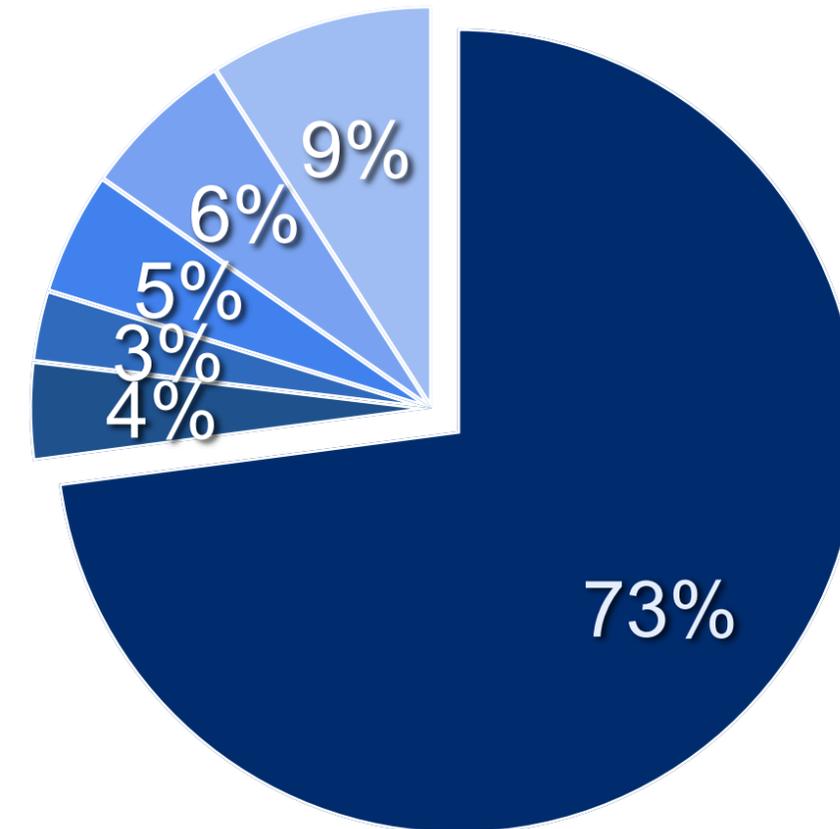


Talking Friends Key Insights

Launch to Present

- Over 400M app downloads to date
- Total video uploads: >750K
- Total views: >345M views
- Emphasis on self expression & story telling
- Demographic Information
 - Varies by topic of video
 - App User Behavior
 - Users create variety of content

Video Uploads



- Talking Tom
- Talking Lila, Hedgehog, Hippo, Rex
- Talking Gina
- Talking Bird
- Talking Robot
- Talking Ben



How It Works

Talking Friends Design

- Video is captured at 320x480, 10 FPS, MOV (MPEG4 + AAC)
- YouTube metadata included with the direct upload helps with discovery
- Tags (“[...]funny animation funny cartoon Outfit7 Outfit7TalkingBen[...]”)
- Download link included in metadata description (“<http://o7n.co/Ben>”)

