Outernauts: From AAA Console to AAA Flash

Joe Valenzuela
Insomniac Games

GAME DEVELOPERS CONFERENCE®
SAN FRANCISCO, CA
MARCH 25–29, 2013
EXPO DATES: MARCH 27–29
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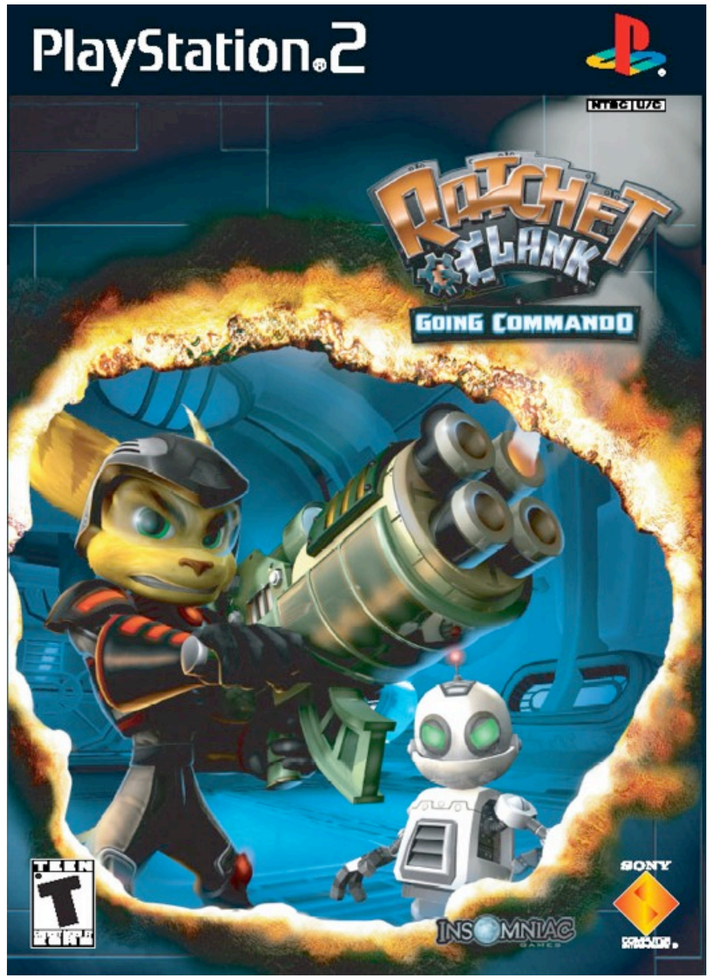
Insomniac Games



Friday, April 19, 13

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NEW QUEST
NEW QUEST
NEW QUEST
NEW QUEST

Basic Info

- Flash/AS3 game client
- LAMP on Amazon (AWS) app servers
  - nginx load balancing
- REST based app server
- dbShards with mysql interface

Terminology

Tile

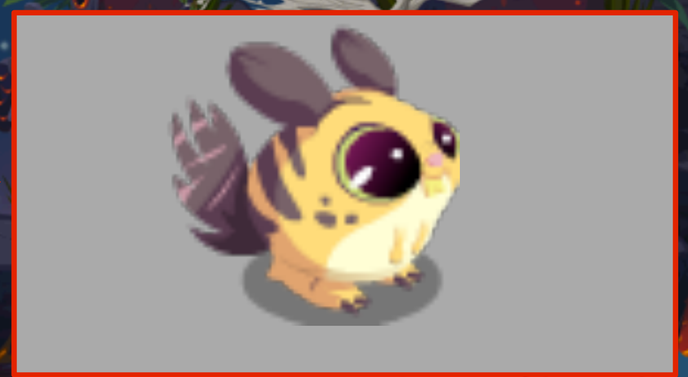
Star Map

Homeworld

Party

Razorweed Moon: Crust

Moby



Star Map

Homeworld

Party

Razorweed Moon: Crust

flash.display.*
DisplayObject
Bitmap
Shape
Sprite
MovieClip
Star Map
Homeworld
Razorweed Moon: Crust
Party

DisplayList

Shape

MovieClip

↳ Bitmap

MovieClip

↳ Shape

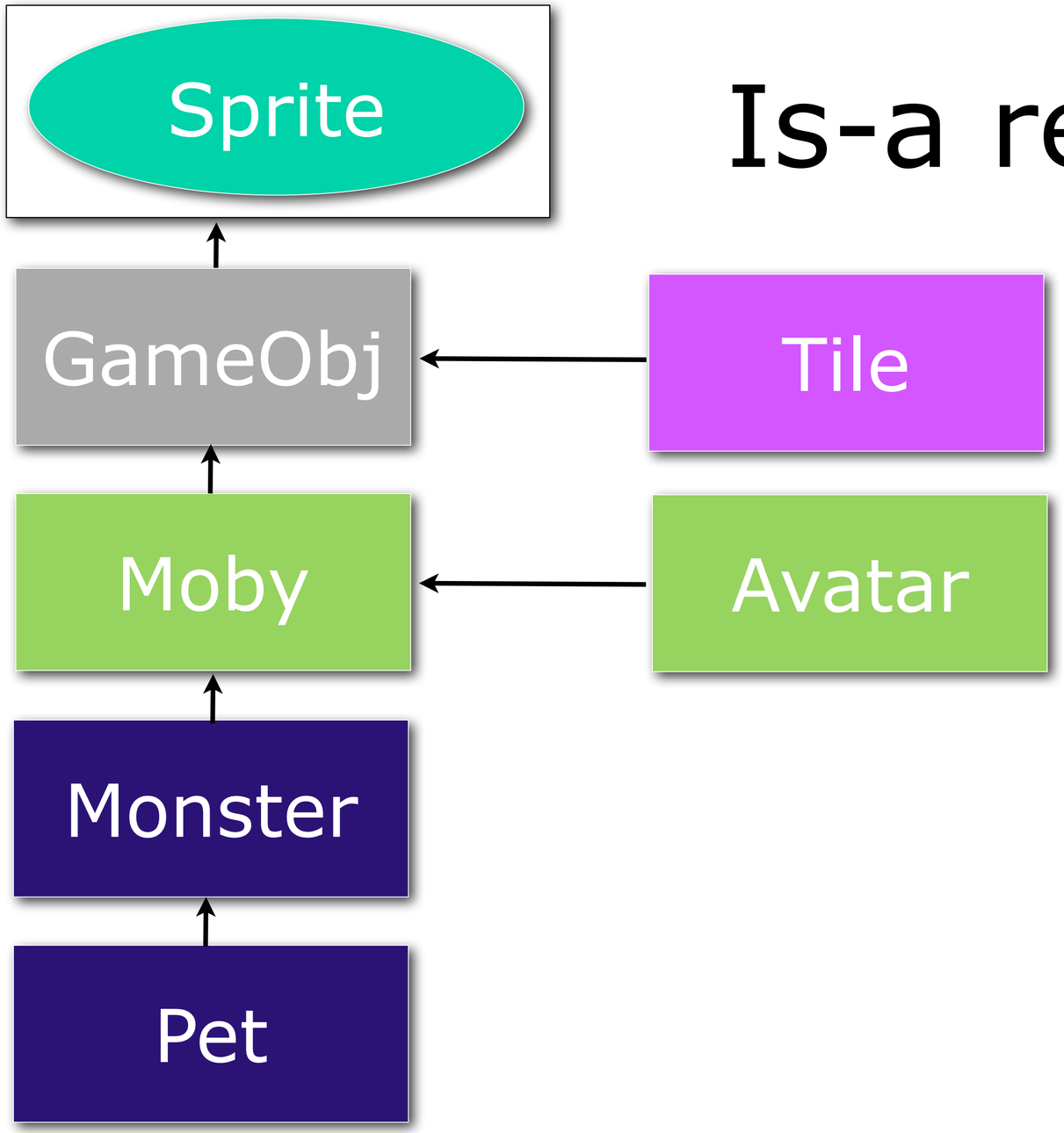
Outernauts metrics

- 52 production levels
- 5968 assets
  - 786 audio files
  - 1599 avatar/890 monster animations
  - 1240 tiles
- ~150000 LOC (ActionScript3)
- ~20 man-years

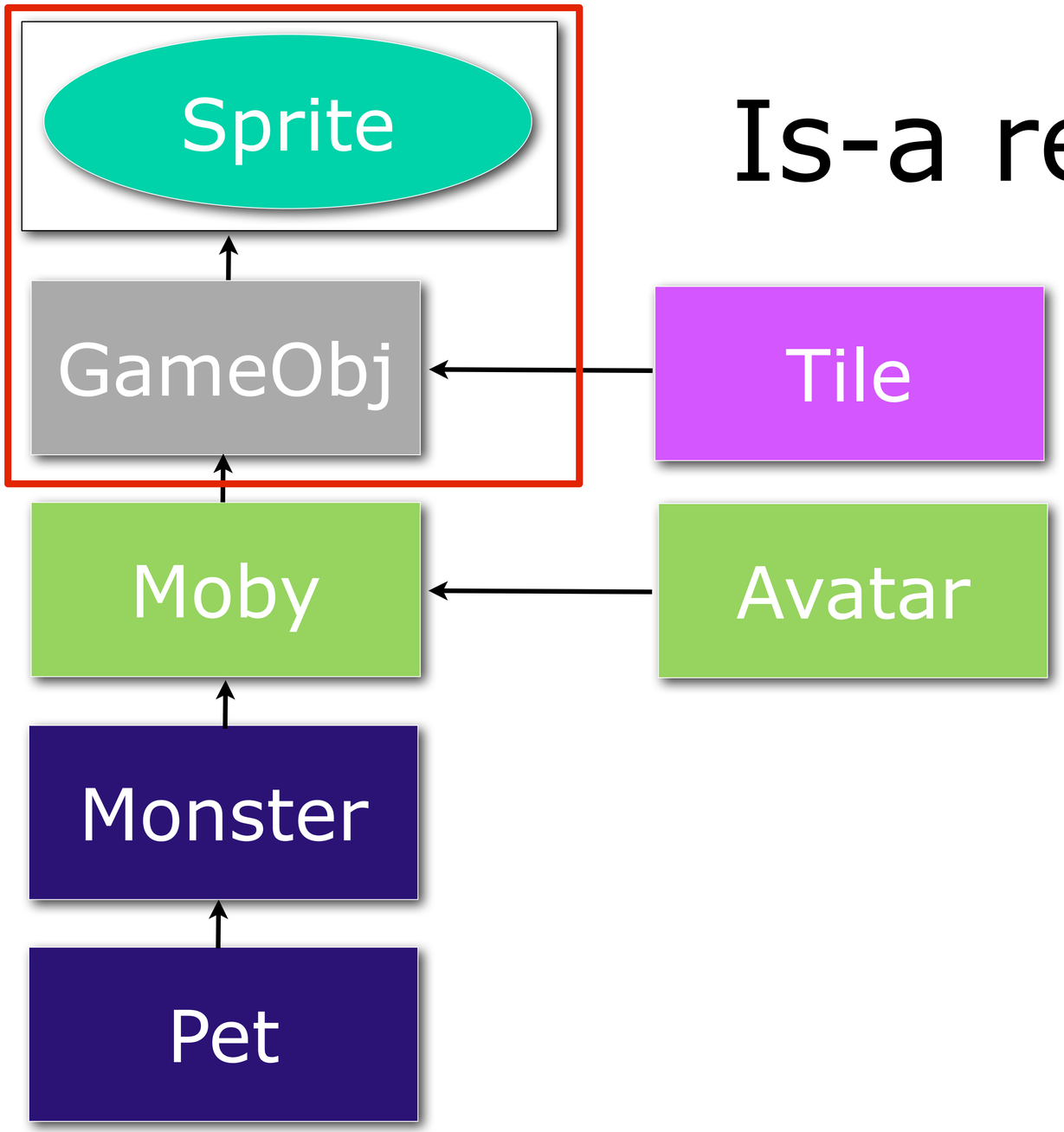
Lessons

- Flash
  - Vector DisplayObjects: use judiciously
  - Keep DisplayList short & simple
  - Idioms reflect scale
- Retain your best practices
  - Memory rigor
  - Separate simulation vs rendering

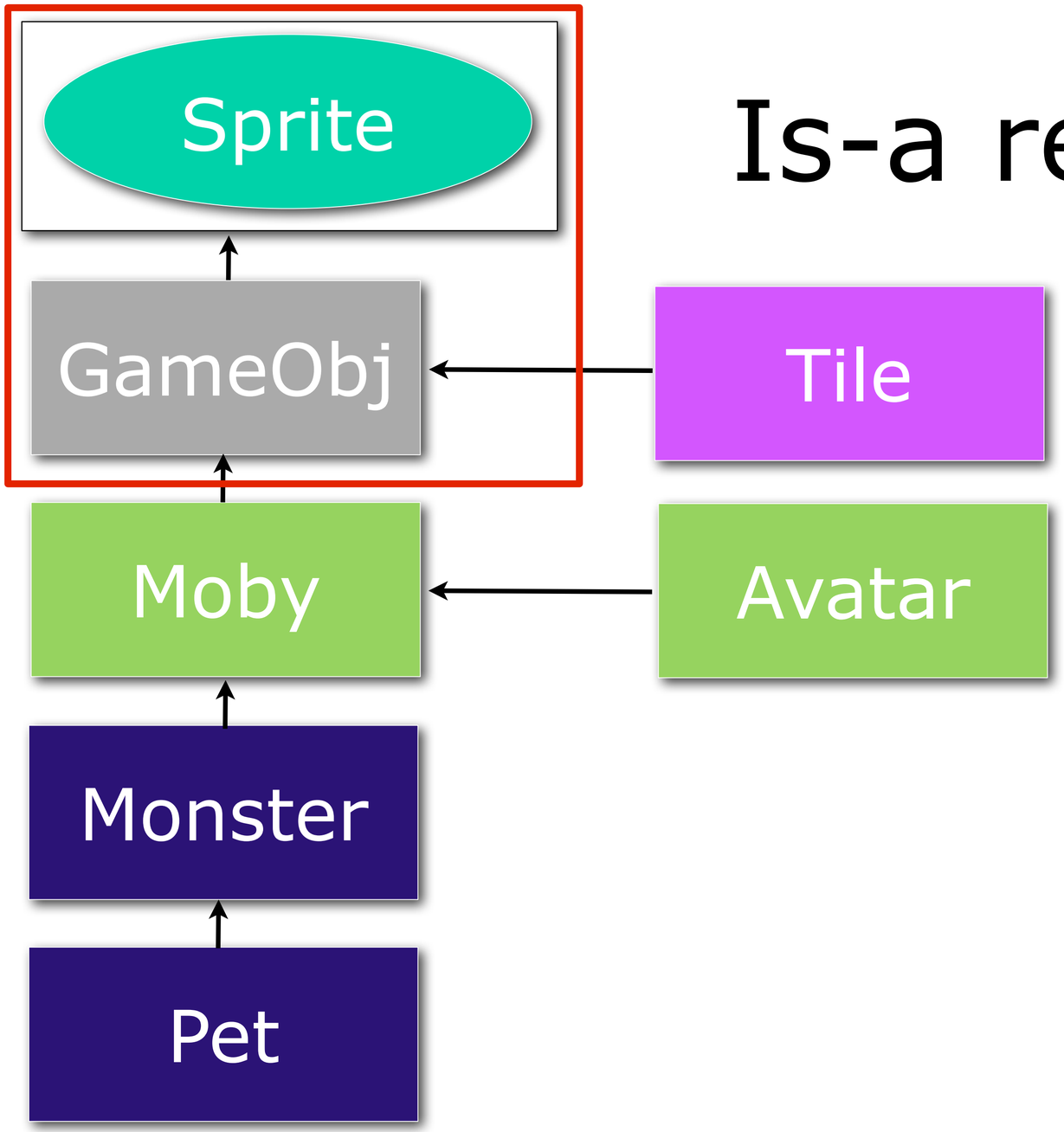
Is-a renderable



Is-a renderable



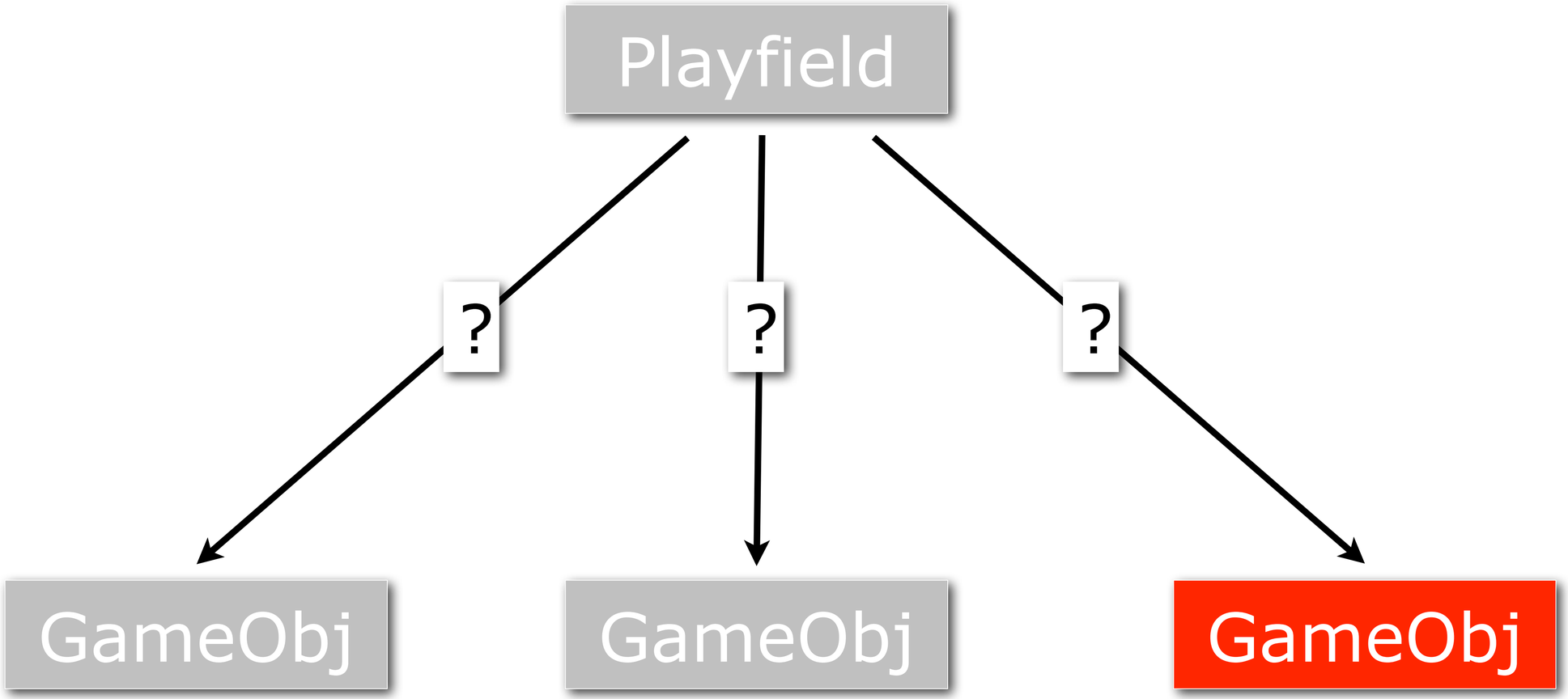
Is-a renderable



CPU: hotspots

- GC costs
- Stringy
- Flash Anti-Patterns

Event Mania



Event Mania

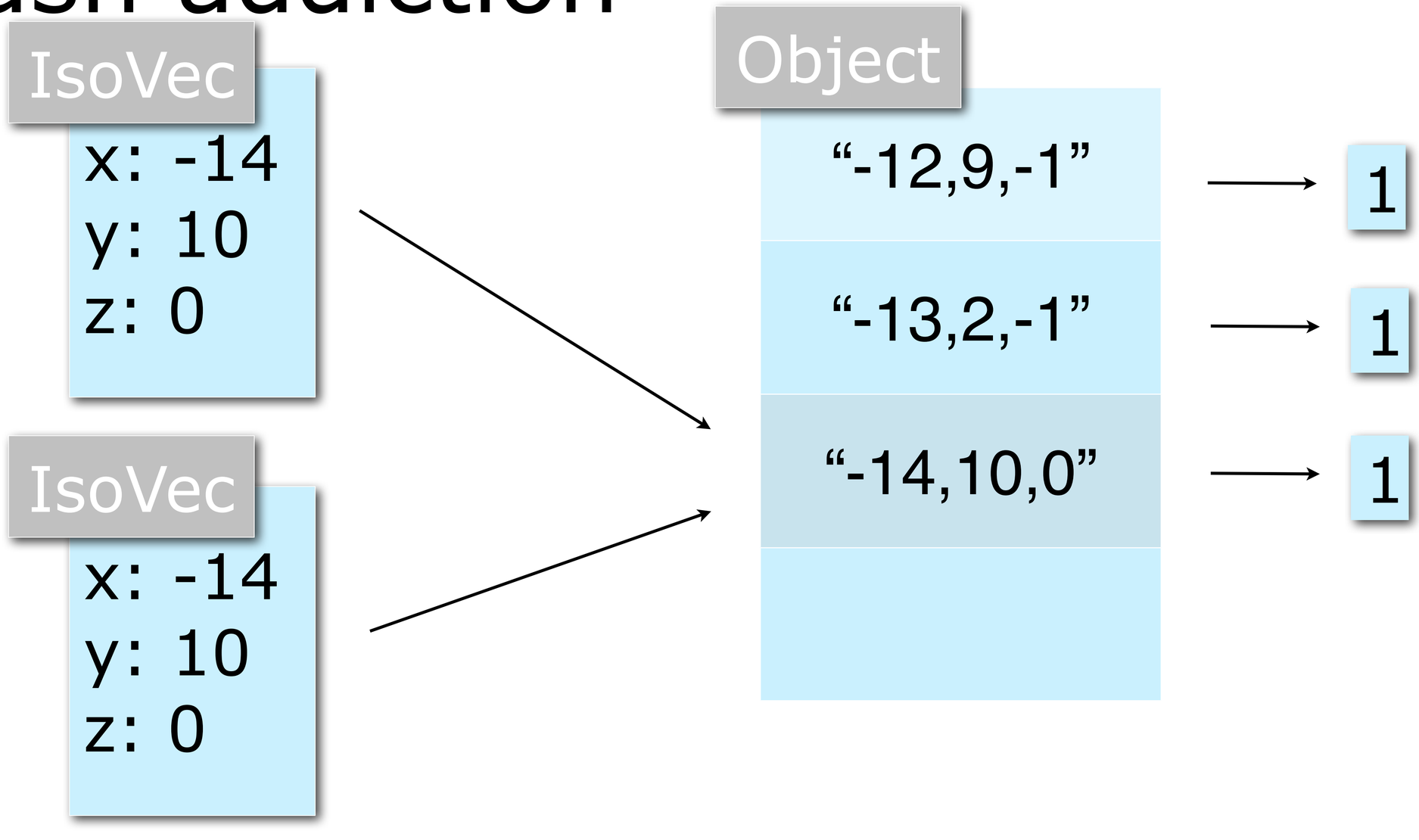
GameObj

```
private function set x(value:Number):void {
    super.x = value;
    dispatch(CustomEvent(GameObj.CHANGE_POSITION));
}

private function set y(value:Number):void {
    super.y = value;
    dispatch(CustomEvent(GameObj.CHANGE_POSITION));
}
```

Compulsive Listening

```
{
  for each (var obj:GameObj in getAllObjects())
    obj.addEventListener(GameObj.CHANGE_POSITION,
                         doStuff);
}

static public function doStuff(e:Event):void {
  var gameObj:GameObj = e.target as GameObj;
  if (gameObj.isSpecial())
    doSomething(gameObj);
}
```

Hash addiction



Abstractogeddon

Player

id: 200015
name: Joe Valenzuela
pets: [...]
xp: 576
level: 5

IoTrackedClass

IoTrackedField

name: “xp” value: “576”

IoTrackedField

name: “level” value: “5”

IoTrackedField

name: “pets” value:[...]

Abstractogeddon

Player

id: 200015
name: Joe Valenzuela
pets: [...]
xp: 576
level: 5

IoTrackedClass

IoTrackedField

name: “xp” value: “576”

IoTrackedField

name: “level” value: “5”

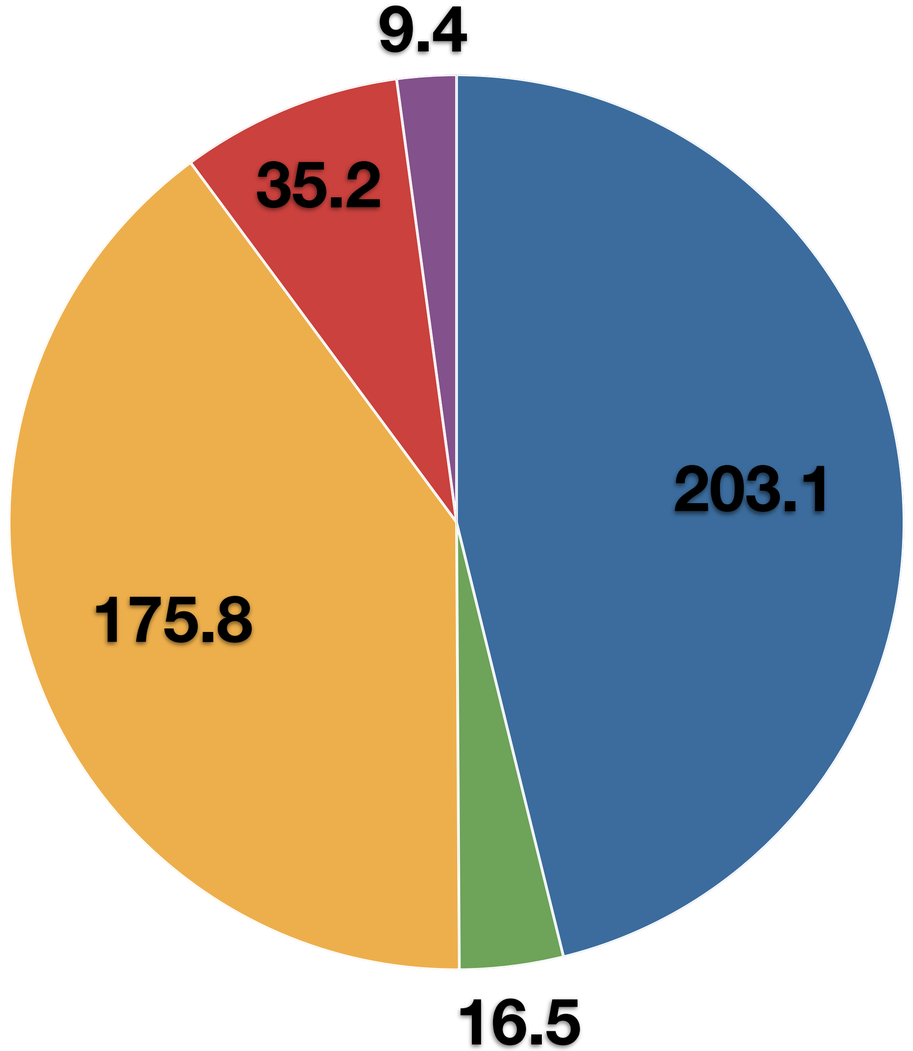
IoTrackedField

name: “pets” value:[...]

```
if (foo["xp"] != oldVal["xp"])
{
  oldVal["xp"] = foo["xp"];
  serialize(foo["xp"]);
}
```

Memory breakdown

- 300-600MB. Peaks to 1GB.
- Bitmap data
- Flash Runtime data
- Volatility



Reducing Memory Volatility

- Object pooling
- Single-threaded scratch space aliasing
- MovieClips (esp offscreen)
- Activation Objects

Activation Objects

- Capture environment (closures)
- Generated implicitly (try/catch, nested functions)
- Affects code generation

Activation Objects

```
public function add0(a:int, b:int):int
{
    return a+b;
}

public function add1(a:int, b:int):int
{
    function dummy():void
    {
    }

    return a+b;
}
```

```
function add0(:int, :int)::int
    getlocal0
    pushscope
    getlocal1
    getlocal2
    add
    returnvalue
```

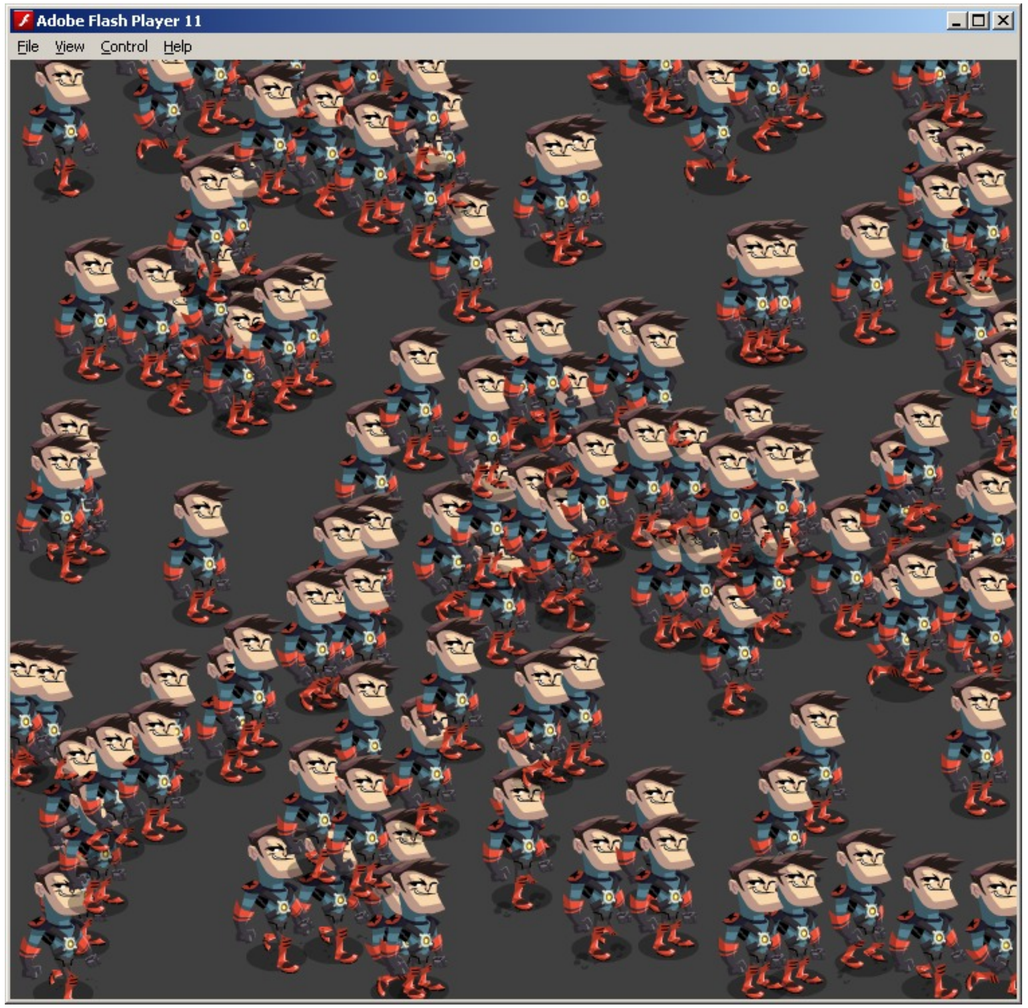
Activation Objects

```
public function add0(a:int, b:int):int
{
    return a+b;
}

public function add1(a:int, b:int):int
{
    function dummy():void
    {
    }

    return a+b;
}
```

```
function add1(:int, :int)::int
    getlocal0
    pushscope
    newactivation
    dup
    setlocal3
    pushscope
    getscopeobject  1
    getlocal1
    setslot         1
    getscopeobject  1
    getlocal2
    setslot         2
    getscopeobject  1
    newfunction     no name
    coerce          :Function
    setslot         3
    getscopeobject  1
    getslot         1
    getscopeobject  1
    getslot         2
    add
    returnvalue
```

Rendering

- Vector slow/Bitmap fast
  - Runtime bitmap conversion
    - Better data sharing
- DisplayList too long
  - Bitmap background



Runtime Bitmap Conversion

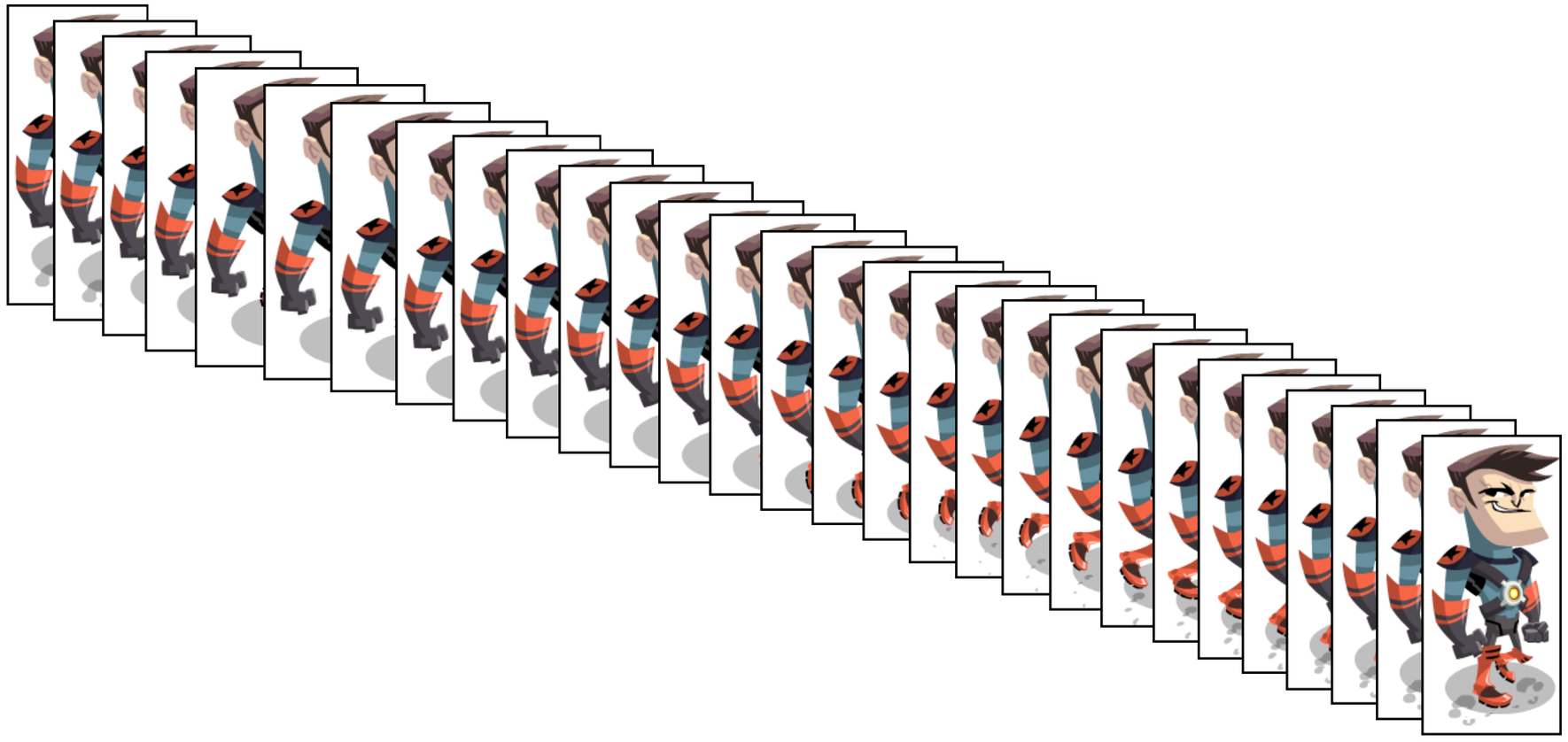
Traditional approach: SpriteSheets

Runtime Bitmap Conversion

Traditional approach: SpriteSheets

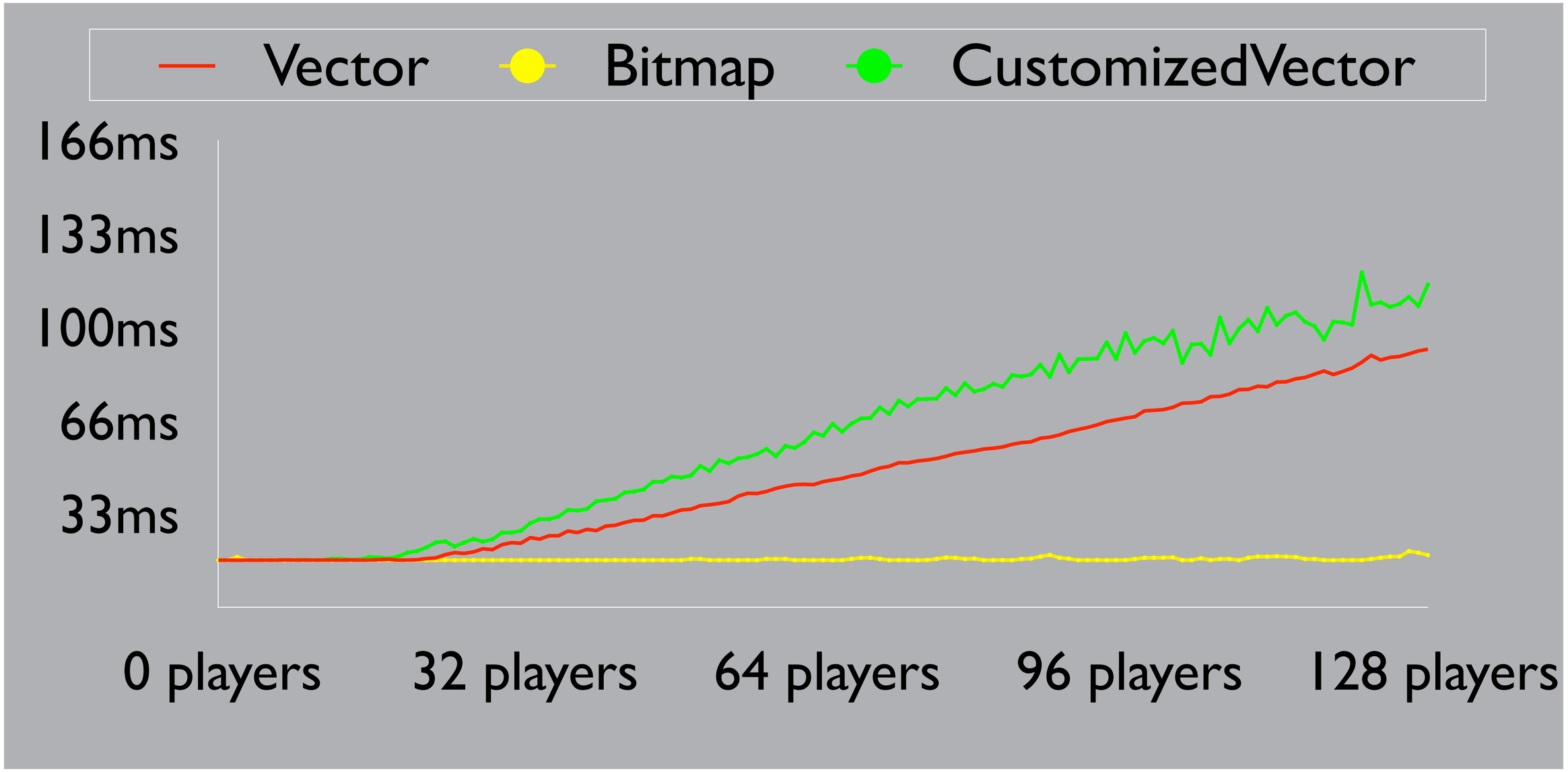
Runtime Bitmap Conversion

Hybrid approach: BitmapData Array



Runtime Bitmap Conversion

Hybrid approach: BitmapData Array


Vector
Bitmap
CustomizedVector
166ms
133ms
100ms
66ms
33ms
0 players
32 players
64 players
96 players
128 players

Bitmap Background

Bitmap Background

- Aqualos region 0: 2371 tiles

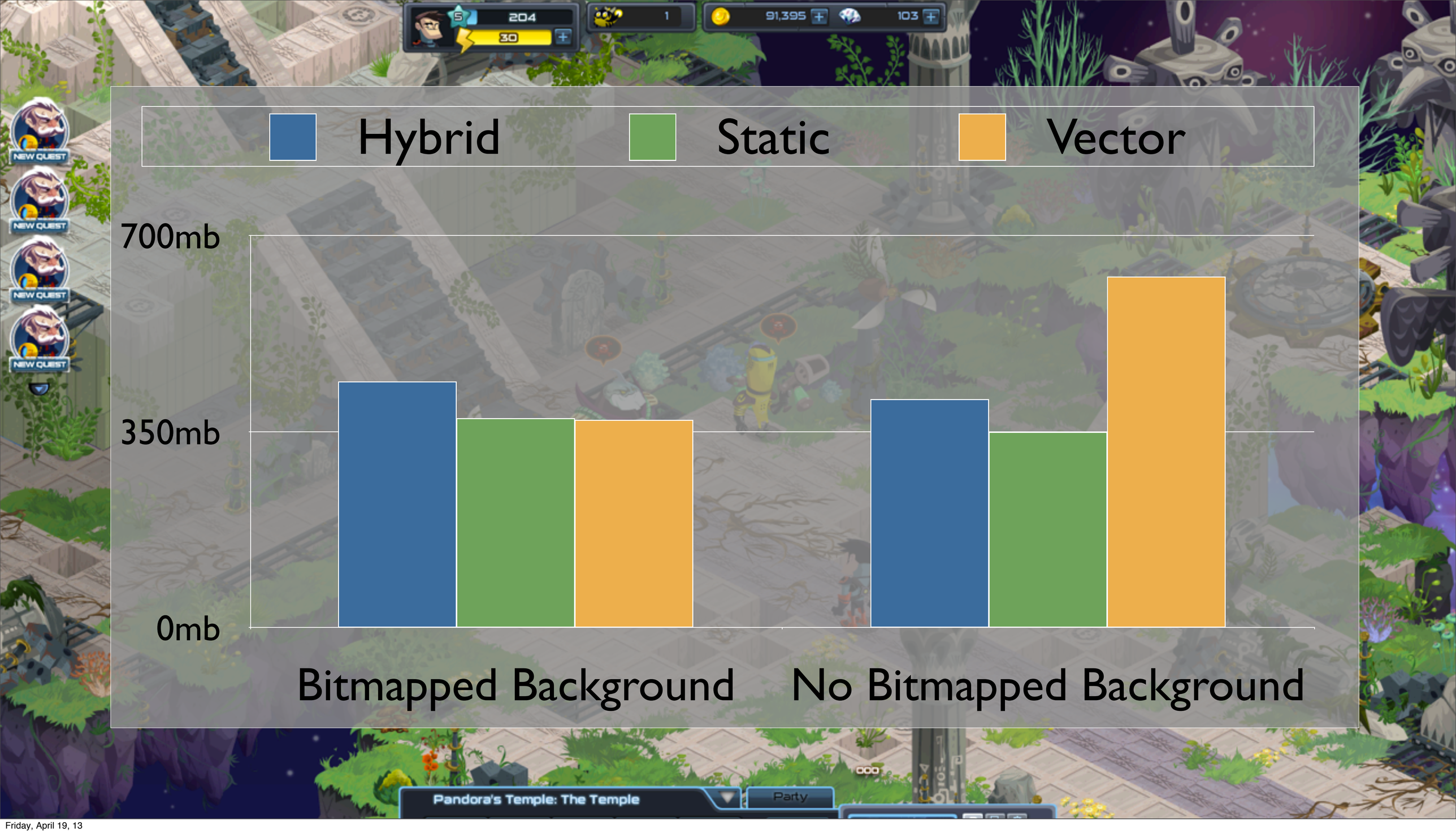
Bitmap Background

- Aqualos region 0: 434 tiles (82%)

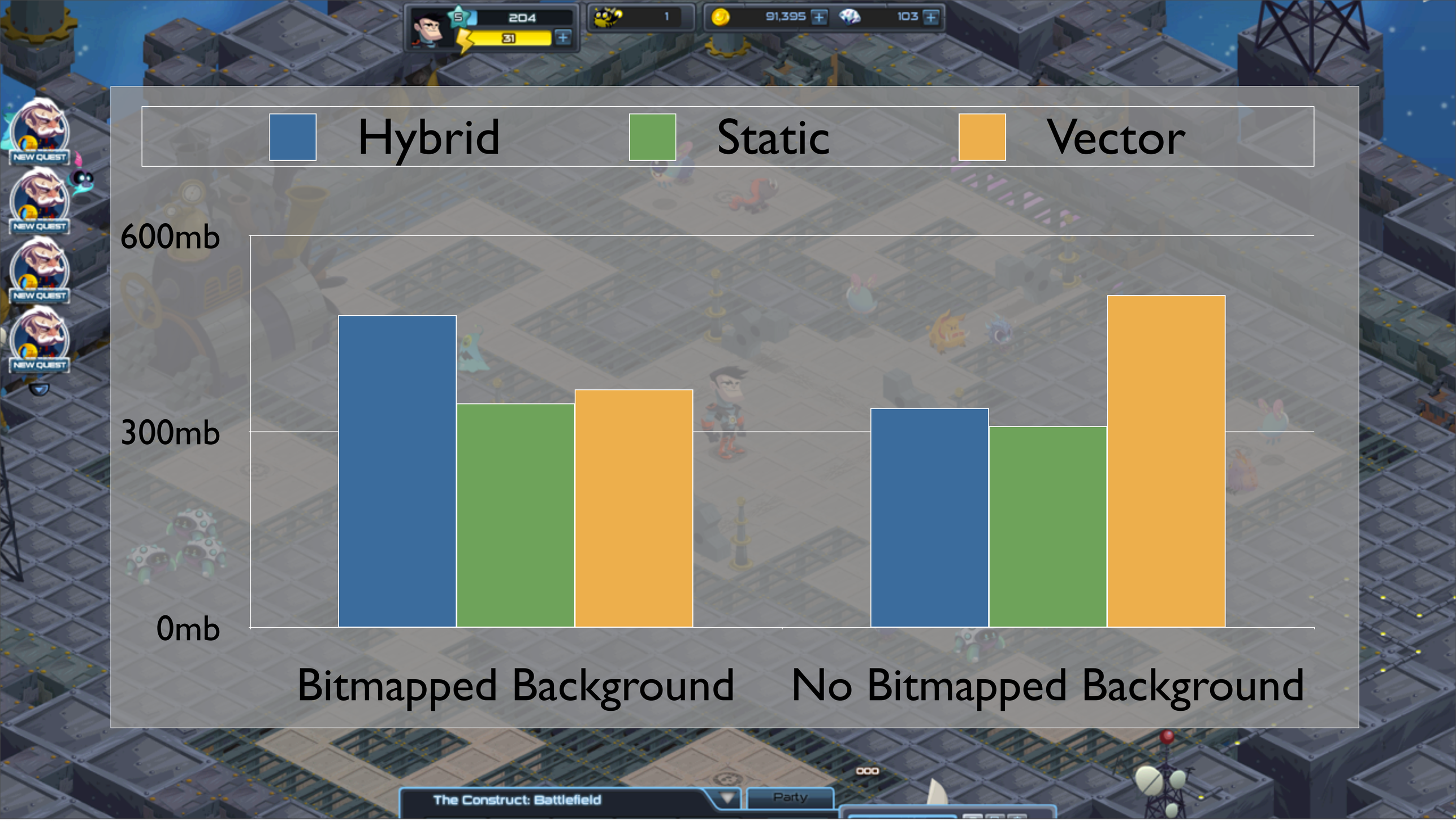
Bitmap Background

- Required separate simulation state from rendering

Hybrid
Static
Vector
30fps
15fps
0fps
Bitmapped Background
No Bitmapped Background


Hybrid
Static
Vector
700mb
350mb
0mb
Bitmapped Background
No Bitmapped Background

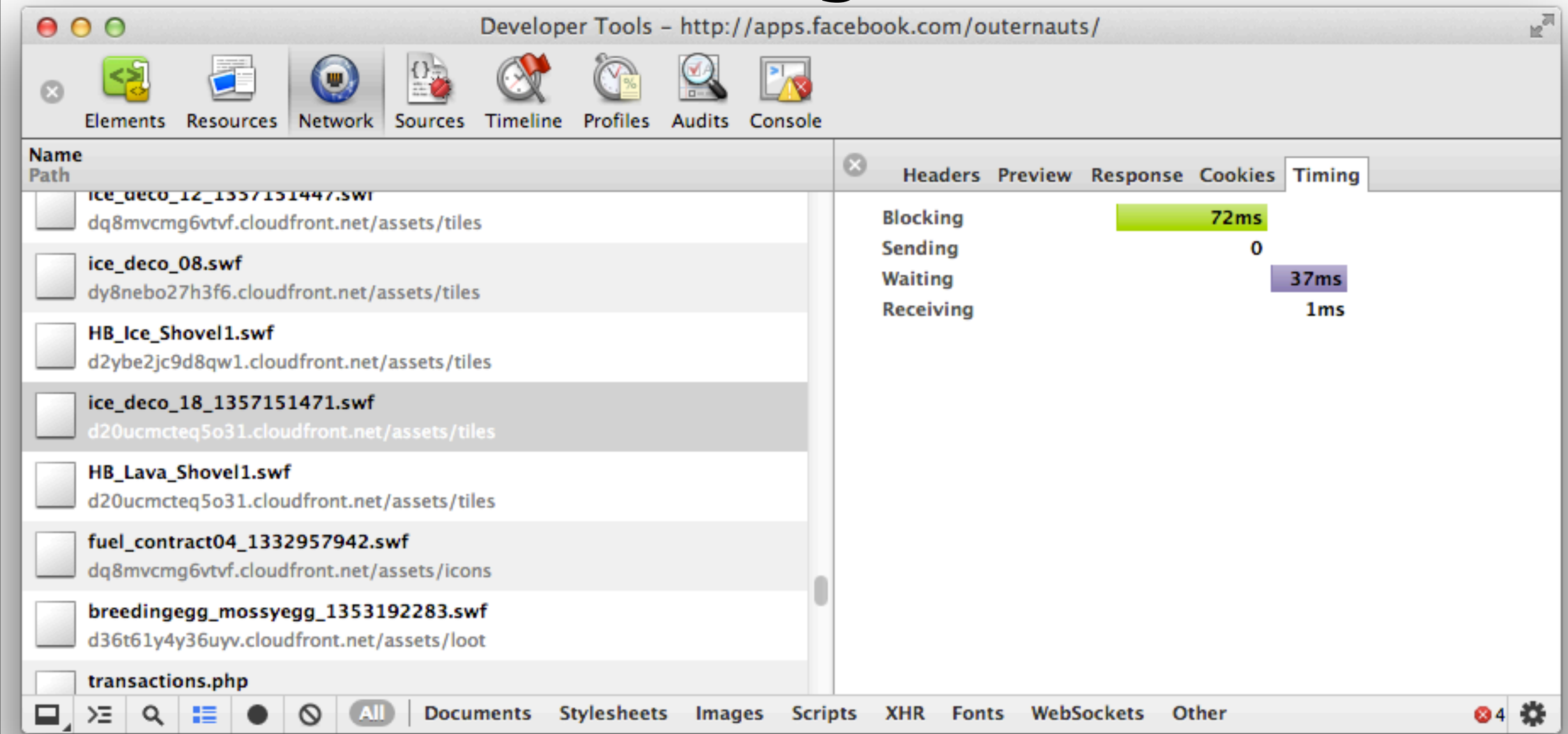
Hybrid
Static
Vector
30fps
15fps
0fps
Bitmapped Background
No Bitmapped Background


Hybrid
Static
Vector
600mb
300mb
0mb
Bitmapped Background
No Bitmapped Background

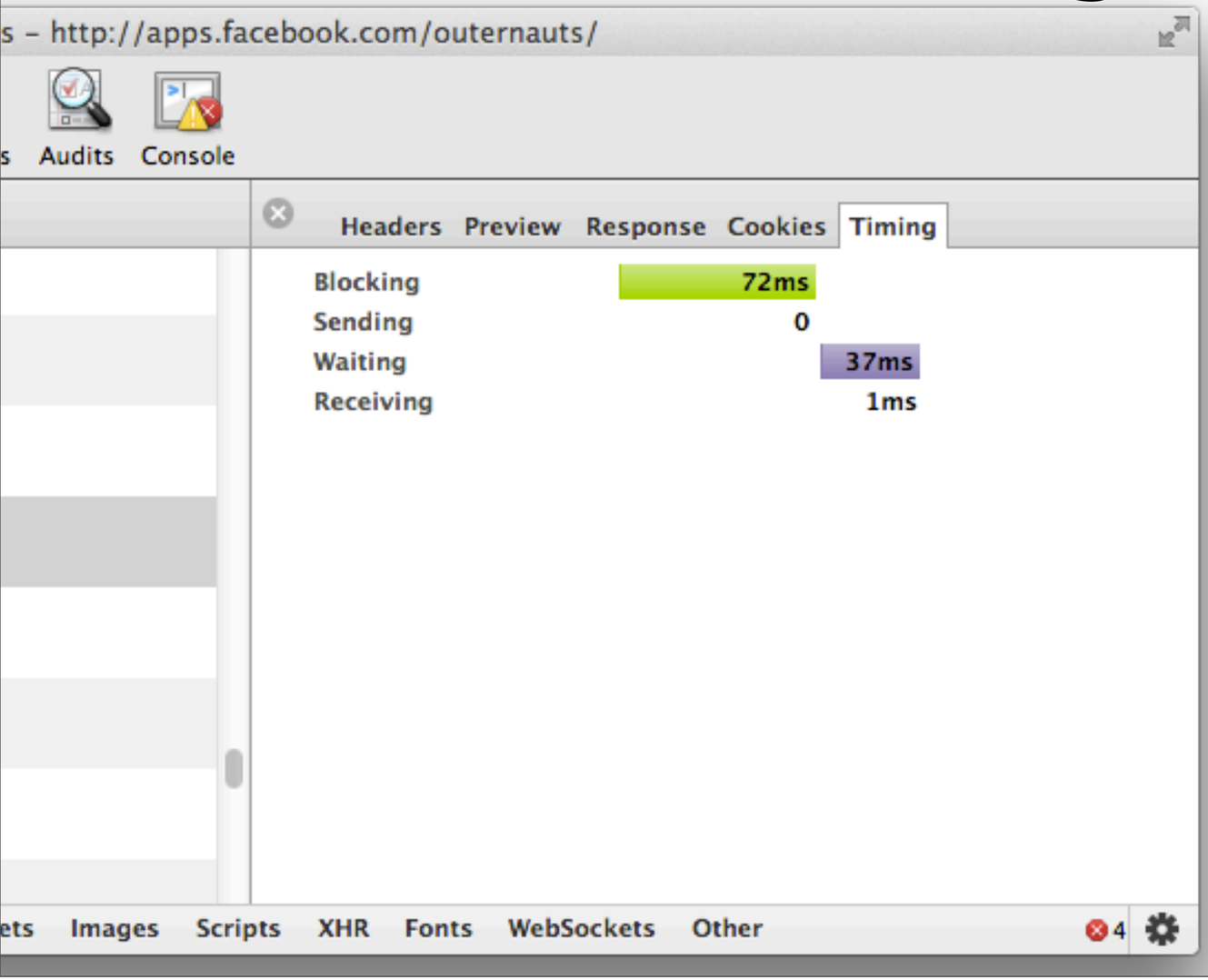
Loading

- ~15MB data download
  - 3MB client, 1MB global data
  - level data, assets
- browser caching
- Content Delivery Network (CDN)
- Aggregated asset loading

Internet Loading

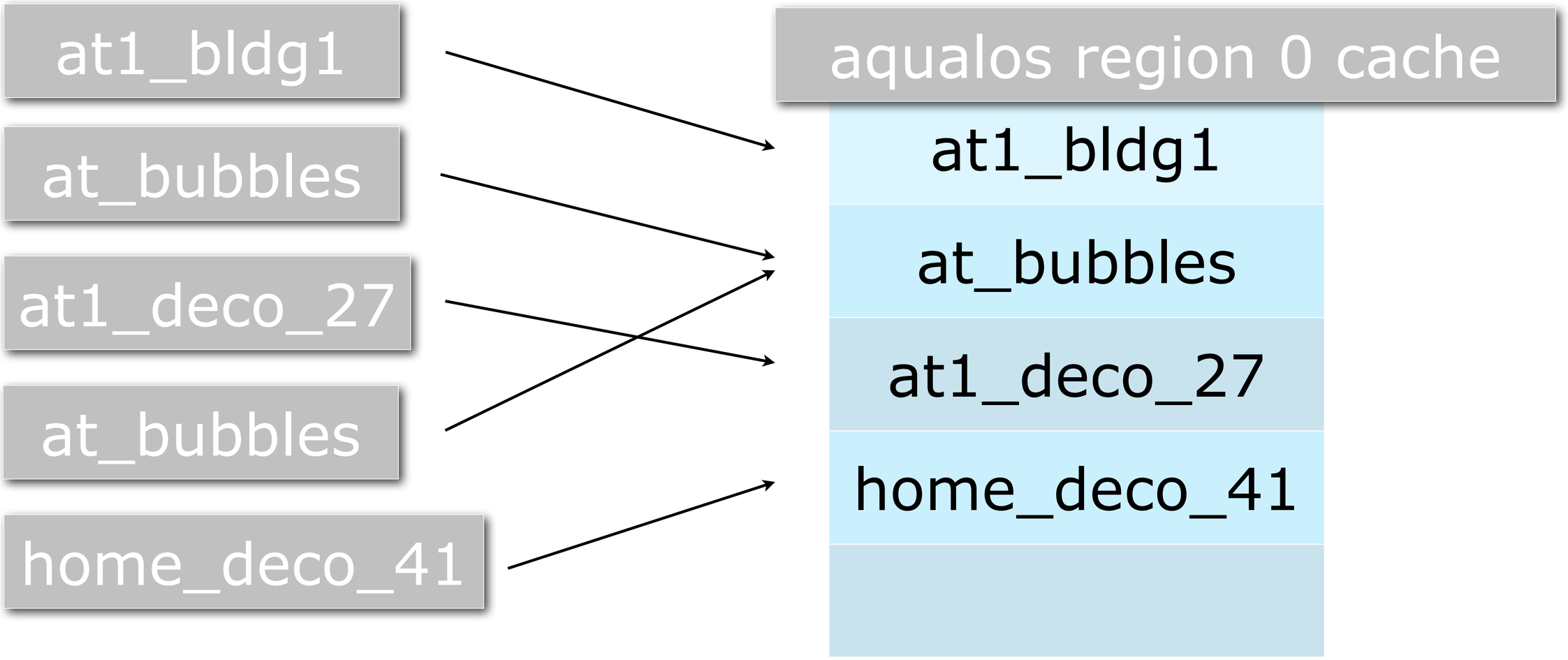


Internet Loading




```
{
   timings: {
    blocked: 72,
    dns: -1,
    connect: -1,
    send: 0,
    wait: 37,
    receive: 1,
    ssl: -1
   }
}
```

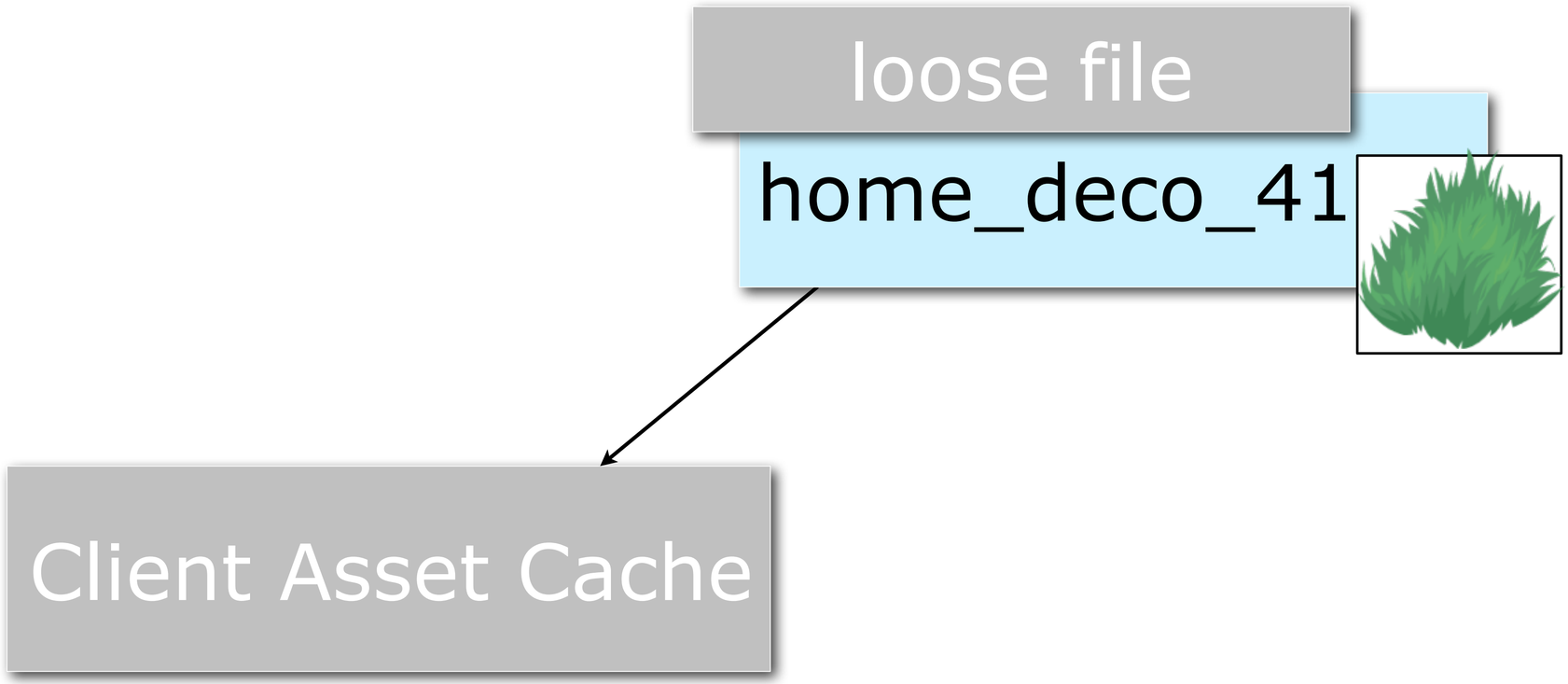
RegionCache: aggregated assets



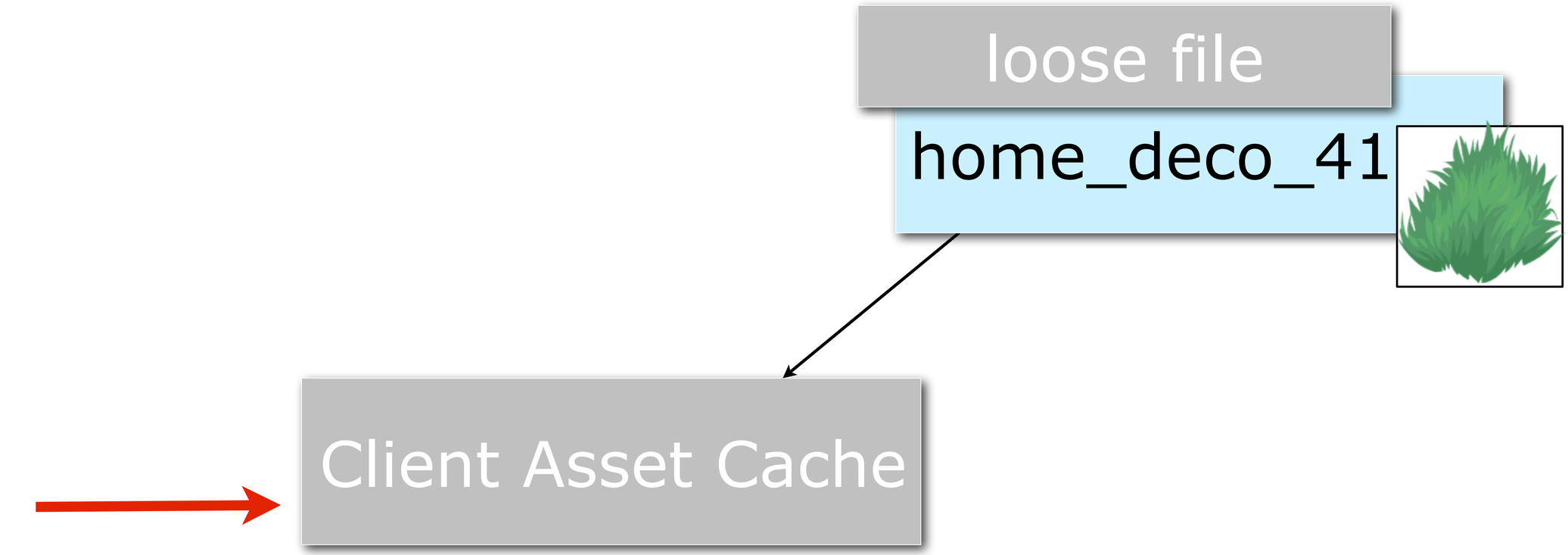
Aggregated SWF: mxmlc toolchain

```
public class aqualos_regioncache_0 extends Sprite
{
  public const version:int = REGION_CACHE_VERSION;
  public const num:int = 1;
  public var swfs:Dictionary = new Dictionary(true);

  [Embed('home_deco_41.swf', mimeType='application/octet-stream')]
  private var aqualos_regioncache_0_0:Class;

  public function aqualos_regioncache_0():void
  {
    var class0:Class = new aqualos_regioncache_0_0();
    swfs["assets/tiles/home_deco_41.swf"] = ByteArrayAsset(new class0);
  }
}
```

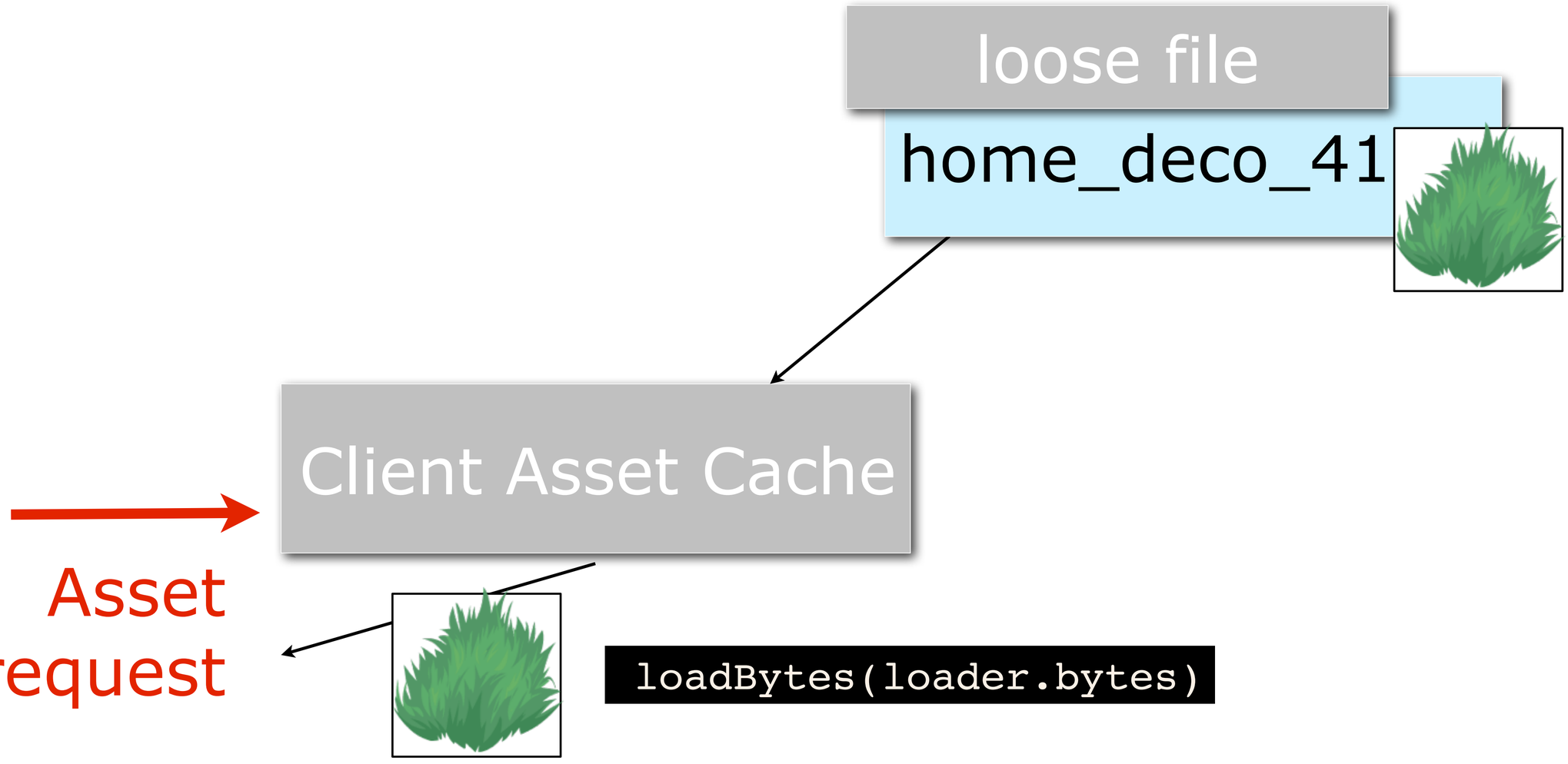
Caching Injection



Caching Injection



Caching Injection

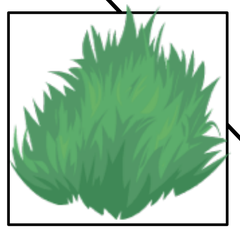


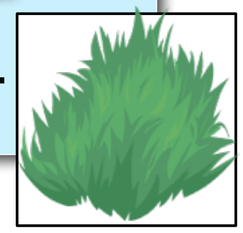
Caching Injection

aqualos region 0 cache

loose file

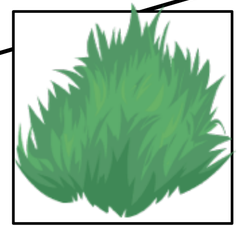
home_deco_41





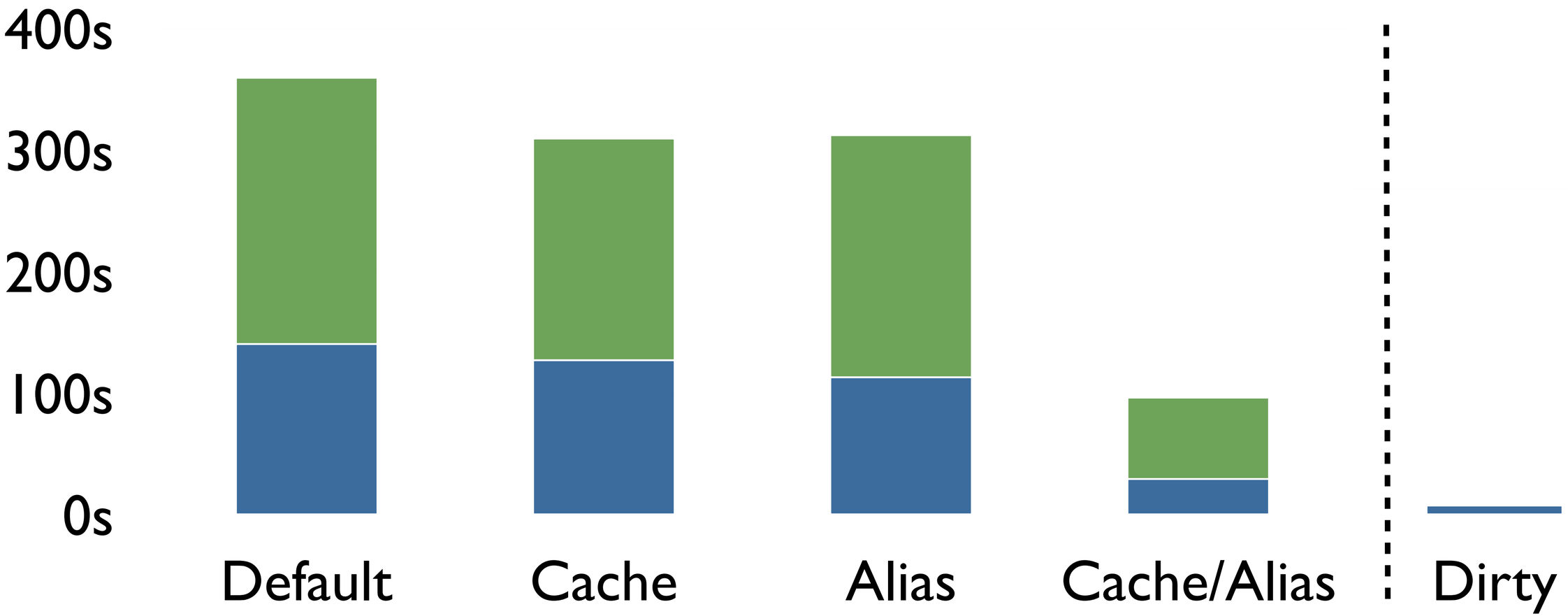
Client Asset Cache

Asset request



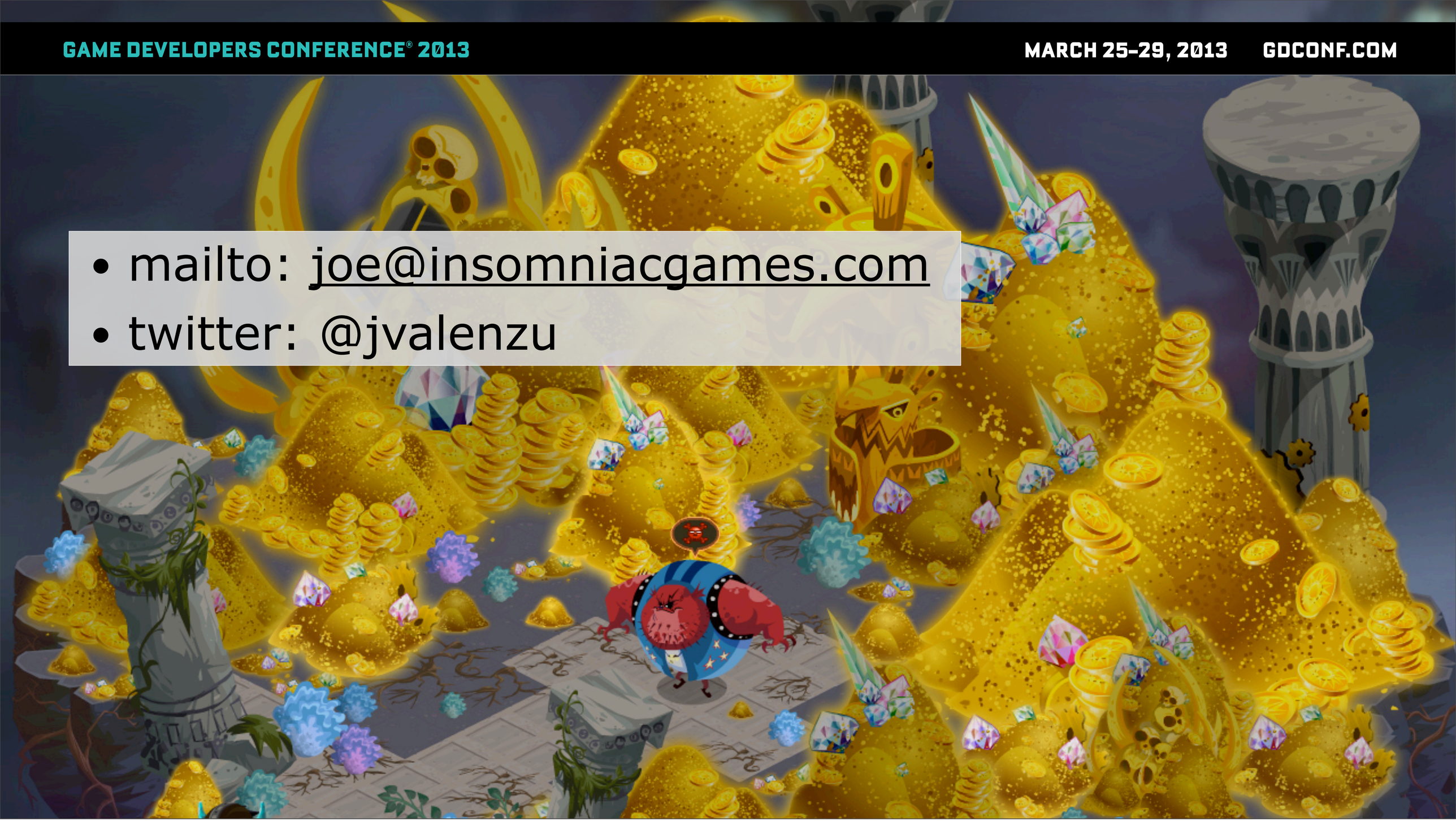
```
loadBytes(loader.bytes)
```

Loading results



Wrap up: Old School still rocks

- Separate simulation/rendering
- Amortized memory allocation
- Eschew strings
- Off-line data processing



- mailto: joe@insomniacgames.com
- twitter: @jvalenzu

Bonus Material!

Defs Editor

Info

name: z_jiv_test id: 167 localized name: JivTest monster_167_name live: false

Aggro

aggro radius: secondary aggro radius:

Evolution

base form: z_jiv_test base id: 167 evolve level: 111 evolves to: z_jiv_test evolution id: 167

Types

type: primal DEL ADD

PRE-ADD

Filenames

filename: pataraur_monster2 frame: anim: idle angle: front xflip: false sound: ver: 1351295100 Update DEL ADD PRE-ADD

filename: pataraur_monster_walk2 frame: anim: walk angle: front xflip: false sound: ver: 1336086117 Update DEL ADD

filename: pataraur_pet frame: anim: idle angle: back xflip: true sound: ver: 1336086118 Update DEL ADD

filename: pataraur_pet_walk frame: anim: walk angle: back xflip: true sound: ver: 1336086118 Update DEL ADD

Scale

scale: 1.3

Tools: WorldBuilder

Attack of the Clones

Class

id: 688
name: Zombie Chomp
type: Phantom
level: 8
power: 270
...
energy: 10

→

Instance

id: 688
name: Zombie Chomp
type: Phantom
level: 8
power: 440
...
energy: 10

→

Override

id: 688
name: Zombie Chomp
type: flying
level: 8
power: 440
...
energy: 10

Attack of the Clones "Solution"

```
private function getNumberKey(key:String):Number {
  if (overrides.hasOwnProperty(key))
    return overrides[key];
  return abilityTagClass[key];
}

private function setNumberKey(key:String, value:Number):void {
  overrides[key] = abilityTagClass[key];
}

public function set accuracy(value:Number):void {
  setNumberKey("accuracy", MathUtils.clamp(value, 0, 1));
}
```

Don’t Panic!

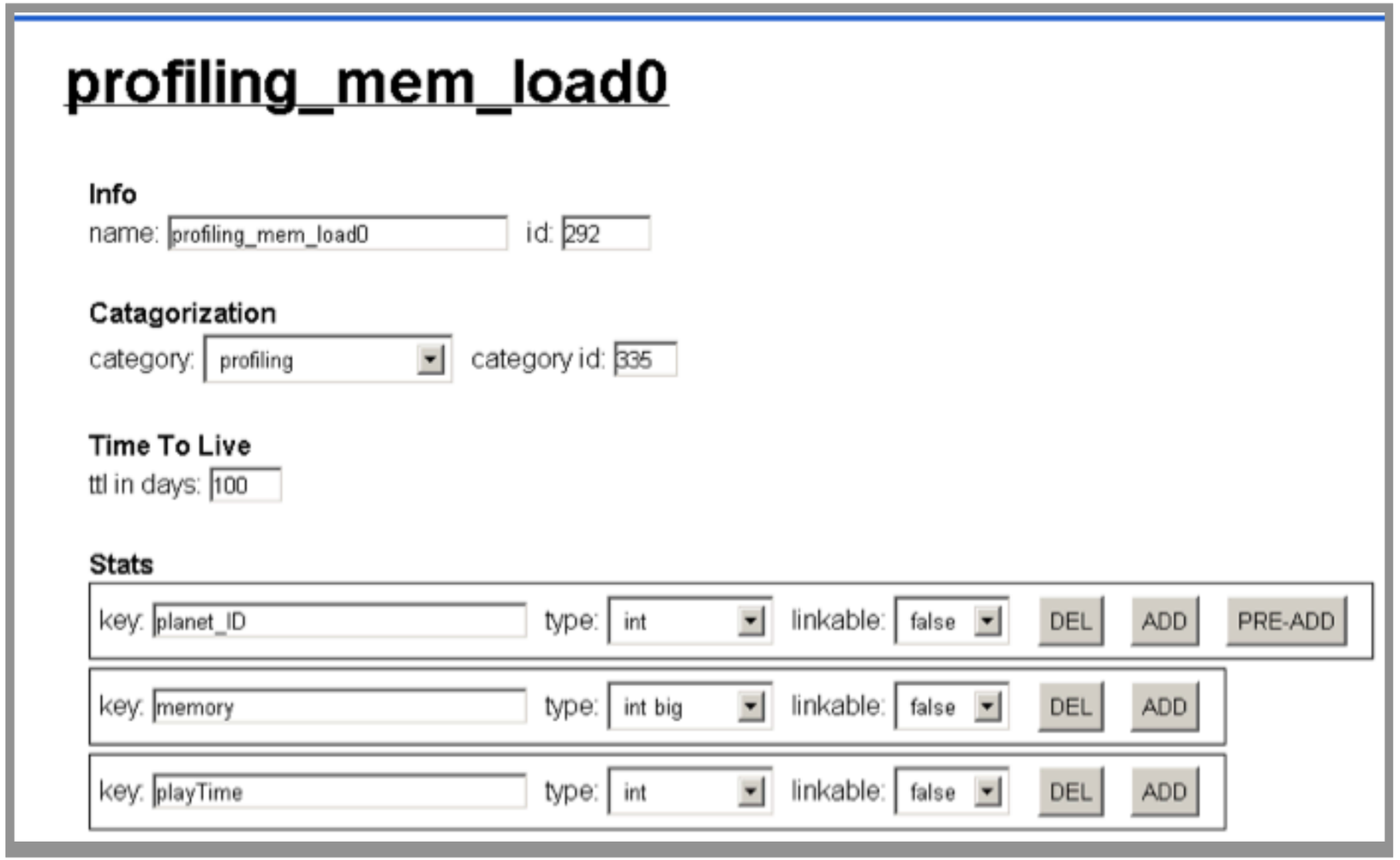
- flash.sampler API
- Interactive/offline tool
- HTML/WebSocket with daemon
- JSON output

247263	64	12928	com.insomniacgames.engine::IsoVec		202
247265	64	12928	Object		
247272	64	12928	com.insomniacgames.engine::IsoVec		
247256	64	12864	Object		
247261	64	12864	__AS3__.vec::Vector.<*>	...	201

```
X:\fl\flash\src;com\insomniacgames\engine\vo;MonsterCollDataVO.as:9
X:\fl\flash\src;com\insomniacgames\engine;Moby.as:1798
X:\fl\flash\src;com\insomniacgames\engine;Moby.as:1887
X:\fl\flash\src;com\insomniacgames\engine;Avatar.as:1291
X:\fl\flash\src;com\insomniacgames\engine;Avatar.as:1486
X:\fl\flash\src;com\insomniacgames\engine;Avatar.as:2942
X:\fl\flash\src;com\insomniacgames\engine;Playfield.as:4675
X:\fl\flash\src;com\insomniacgames\game;Game.as:4185
[enterFrameEvent]:0
```

Stats

- MonetDB
- 300e6 rows
- abstract schema: 16 ints
- Stat browsing



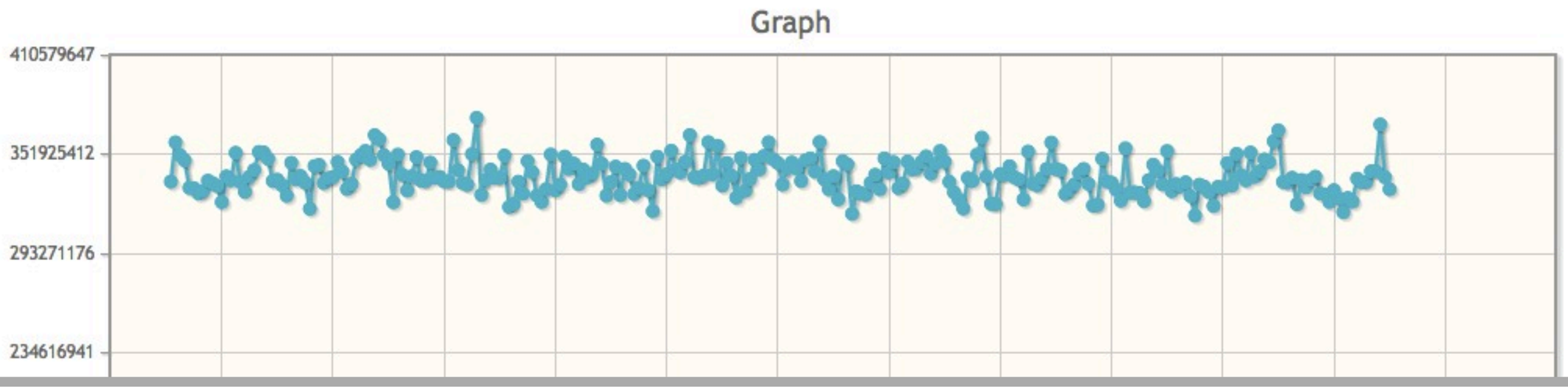
Platform: Facebook Bookmarks: Add Remove

Event: profiling_mem_load0 Function: average stat: memory group by: Graph step: 1 hour
Start Date: 12/21/2012 End Date: 01/01/2013

Conditions:
Stat: playTime Operator: < Val: 1750000
Stat: Operator: = Val:
Stat: Operator: = Val:
Stat: Operator: = Val:

GO!

Status: 264 data points.



Vendor tools & Middleware

- Flash (Flex 4.6), Player Target 10
- PHP, AWS, Cloudfront (CDN – Content Delivery Network), Rightscale, dbShards.
- FDT, Flash Develop, fdb+emacs, Flash, Chrome.

Cache Control

- Unique asset URLs
  - `assets/avatars/fiora_brother_sam_1342053170.swf`
- Explicit versions
- Bust on I/O error

```
<avatar>
    <id>23</id>
    <name>Lunakin_Fiora_Brother</name>
    <filename>
        <filename>fiora_brother_sam</filename>
        <ver>1342053170</ver>
        <anim>idle</anim>
    </filename>
</avatar>
```

Live Flow

Branches

devel

hotfix

weekly_update

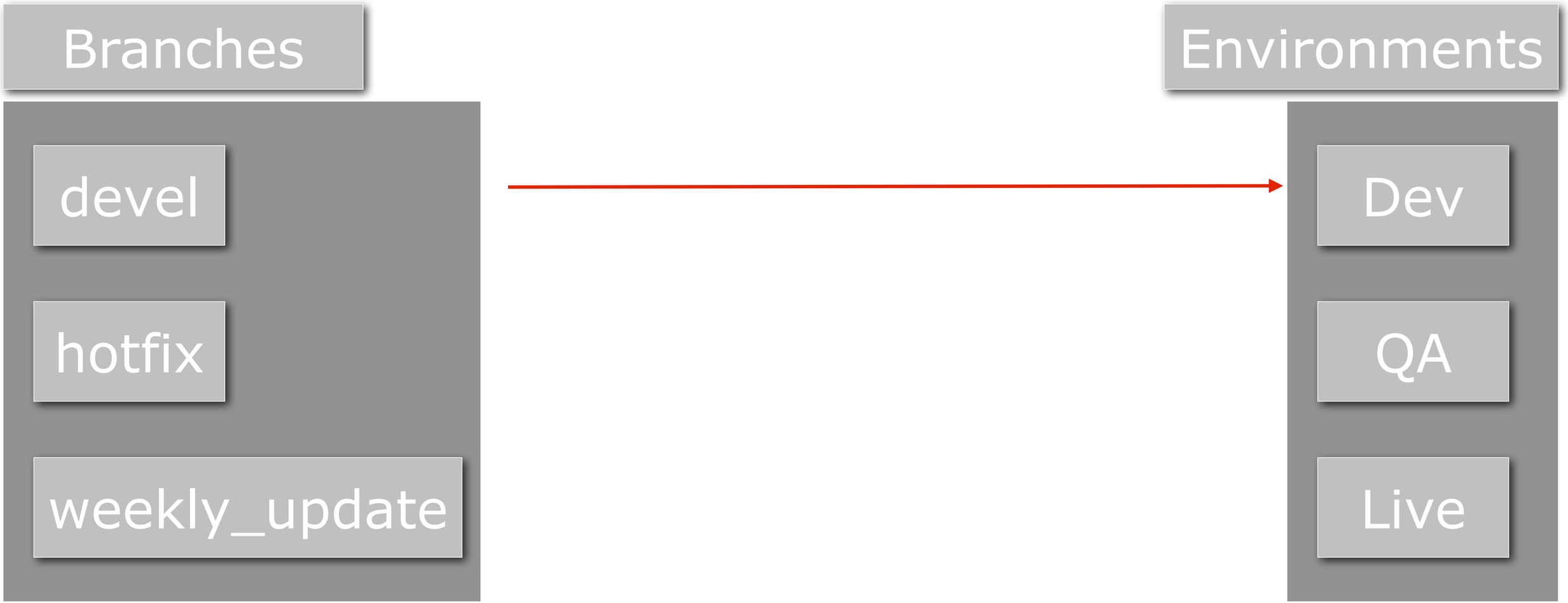
Environments

Dev

QA

Live

Live Flow


Branches
devel
hotfix
weekly_update
Environments
Dev
QA
Live

Live Flow

Branches

devel

hotfix

weekly_update

Snapshot

client (flash)

branched server (php)

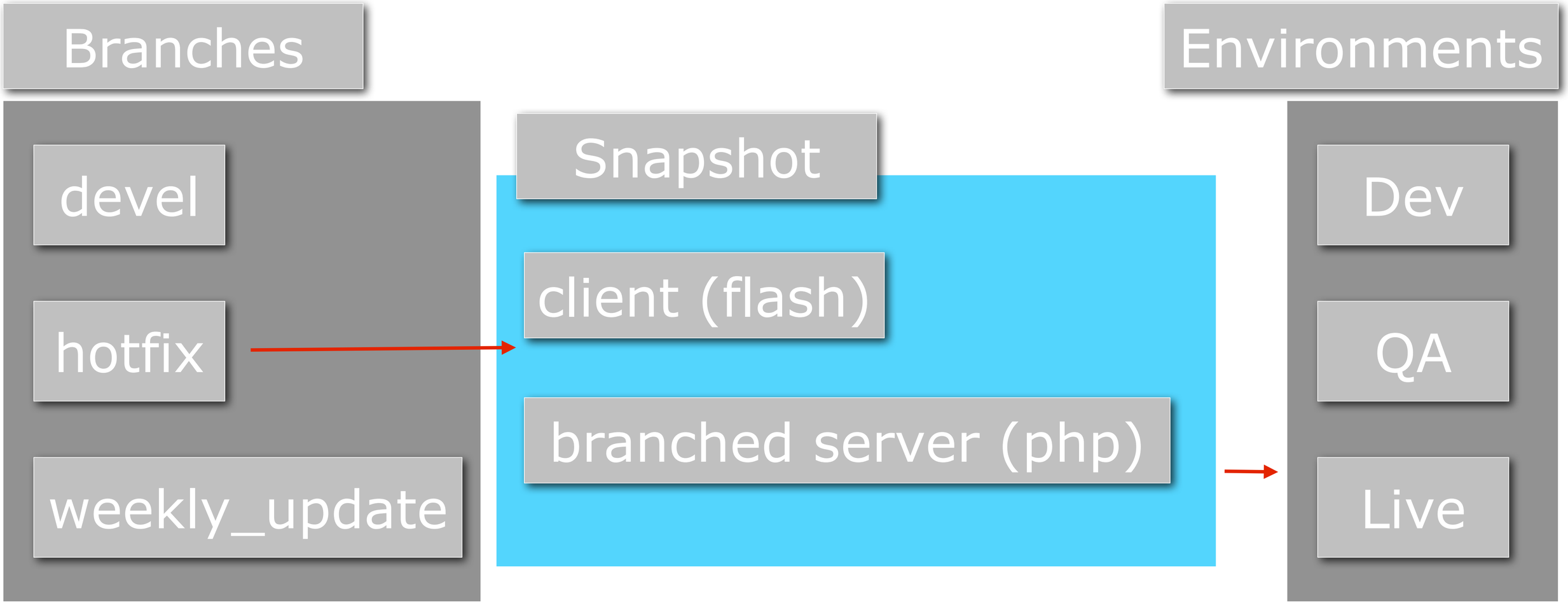
Environments

Dev

QA

Live

Live Flow


Branches
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branched server (php)
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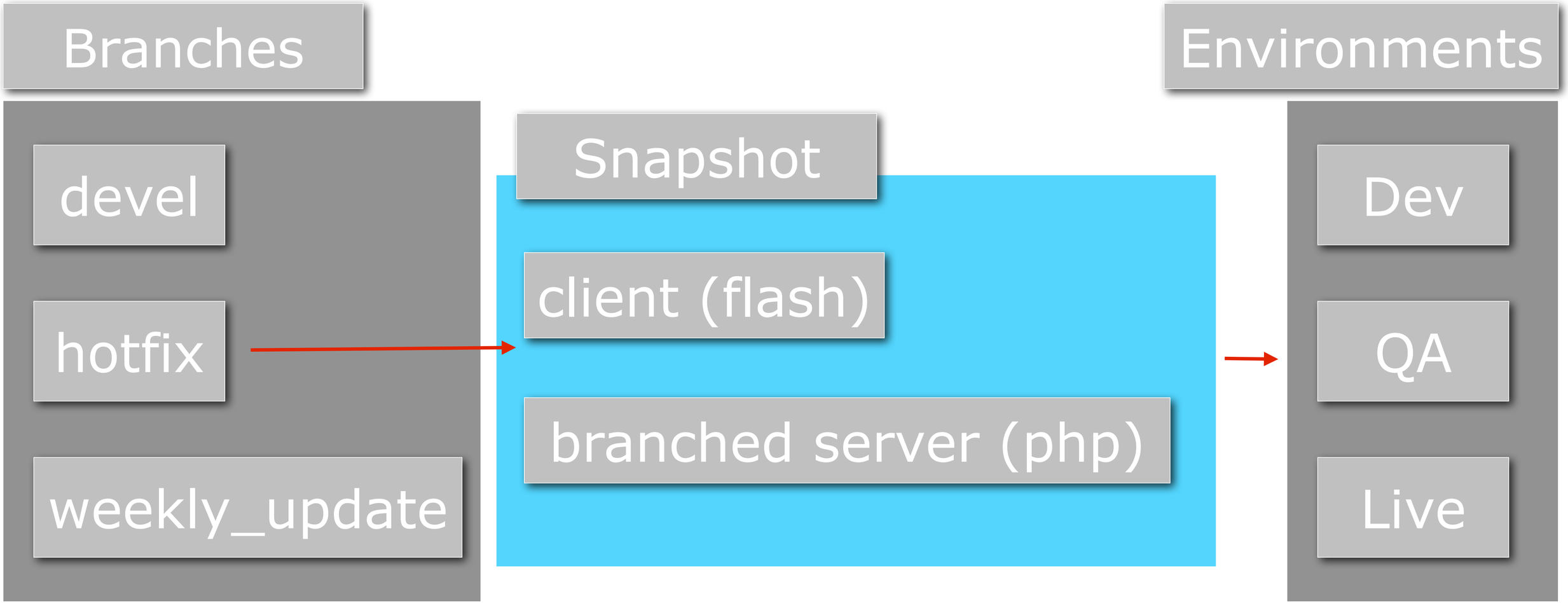
Live Flow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