《诛仙手游》小游戏版

重度MMO手游如何快速移植小游戏平台

完美世界 刘彦麟

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01 Introduction and Overview

02 Transform and Optimization

03 Tuanjie Engine

Introduction and Overview

PART ONE

Introduction and Overview

内容积累 （玩法/功能）

资源复用 （场景/角色/特效）

场景数量： 200+

模型特效： 1W+

PART ONE

Introduction and Overview

PART ONE

Introduction and Overview

特别鸣谢

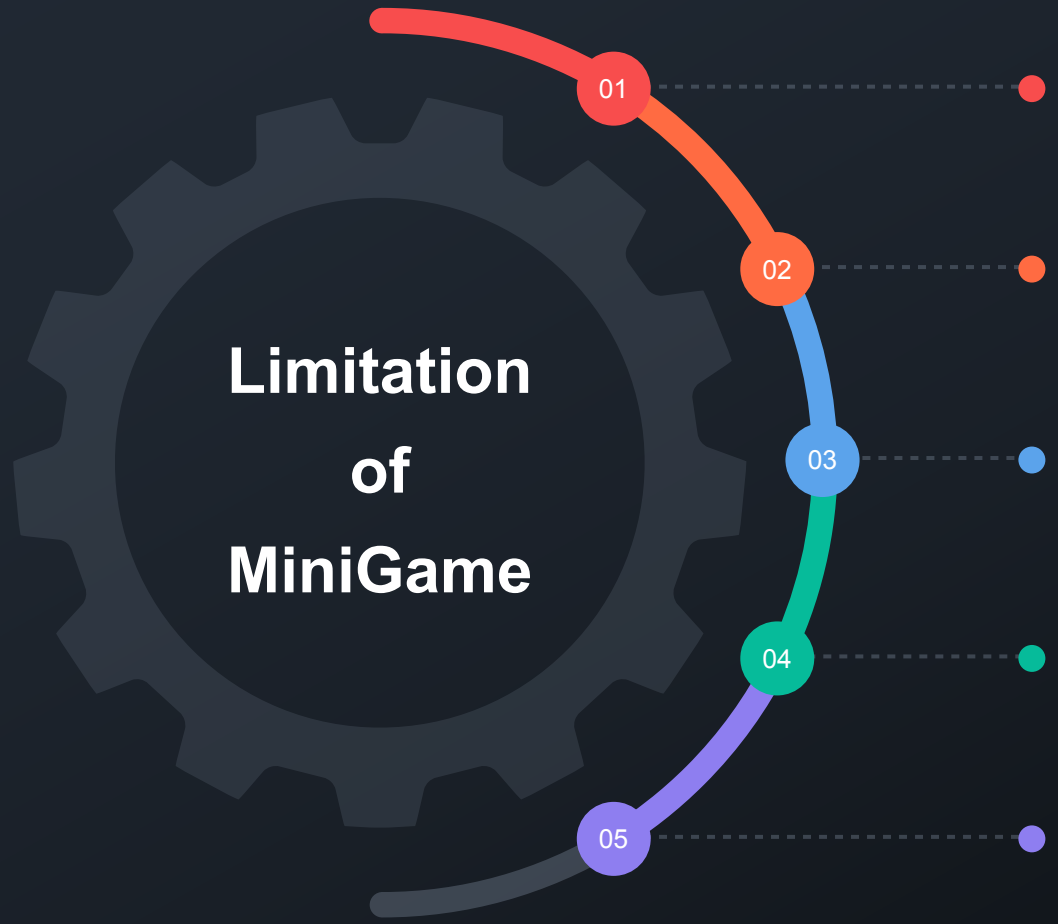
Unity Solution 郑砚及团队

Unity r&d core 赵亮及团队

Transform and Optimization

PART TWO

Transform and Optimization



包体限制 ★

首包 20M / 30M / 100M，Resources，Always Include，Build Setting

文件系统 ★★

200M / 1G / 2G，全异步，额外内存

内存限制 ★★★★★

iOS < 1.4G

CPU开销 ★★★★

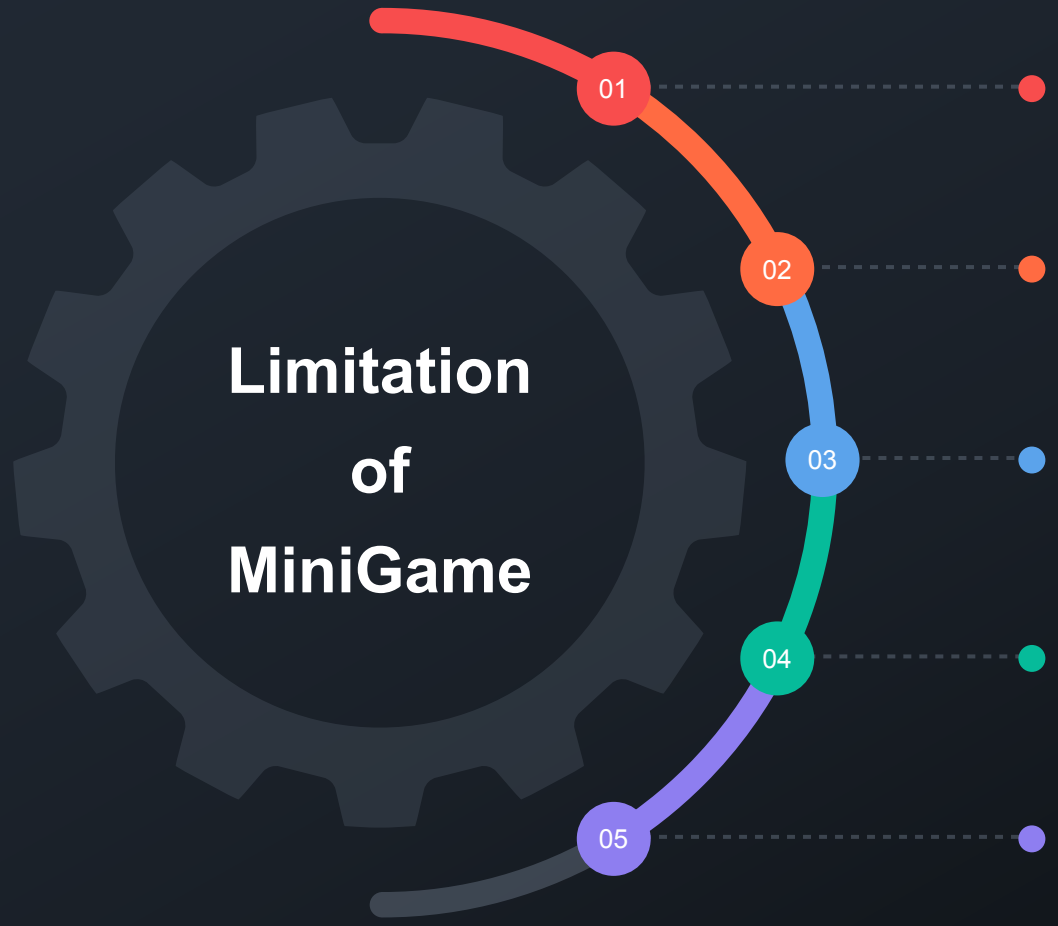
1/3 App，单线程

GPU兼容性 ★★★

WebGL1.0，WebGL2.0，OpenGL3.0

PART TWO

Transform and Optimization



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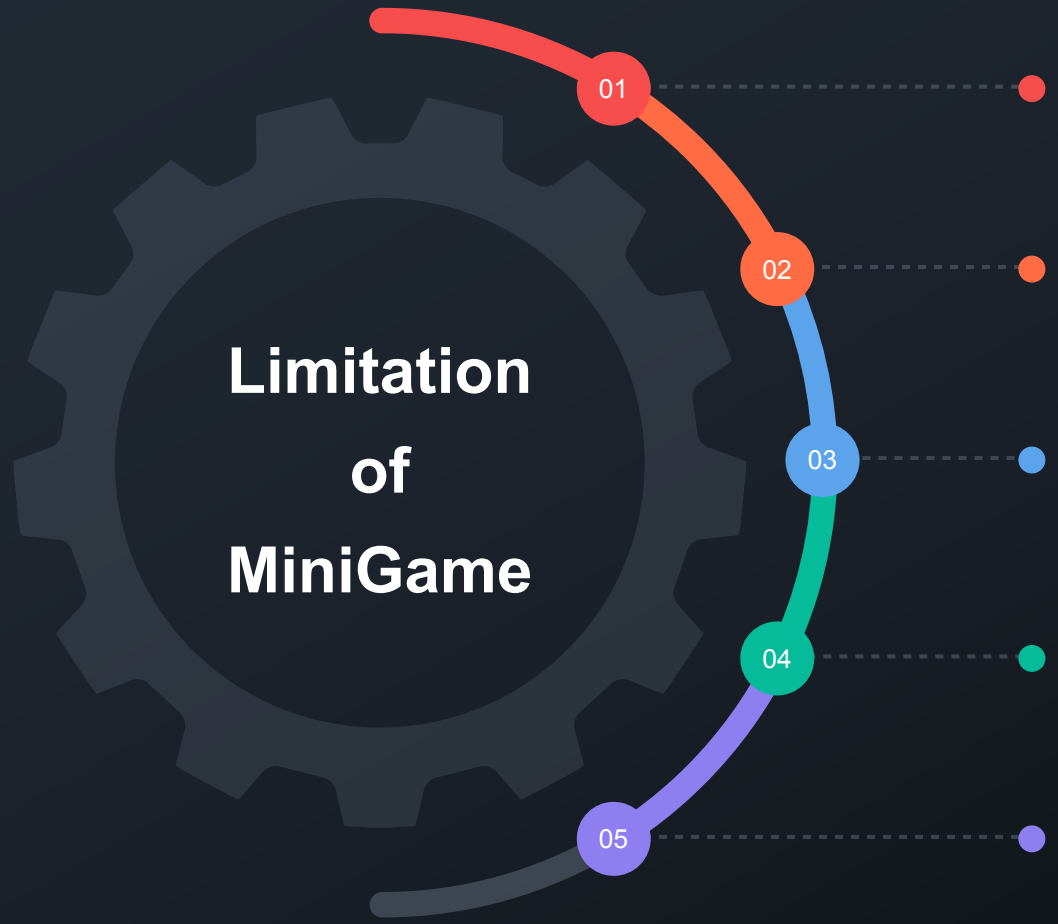

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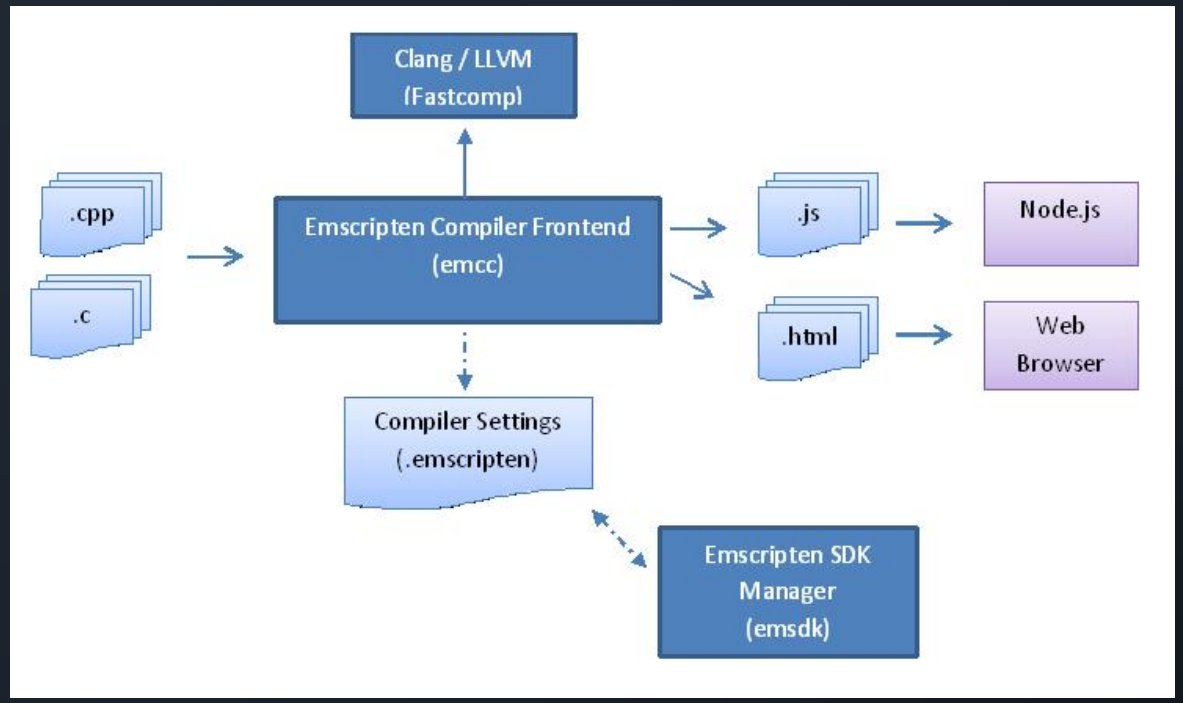
PART TWO

Transform and Optimization

AssetBundle.LoadFromFile()

library_fs.js：虚拟文件系统，自动集成

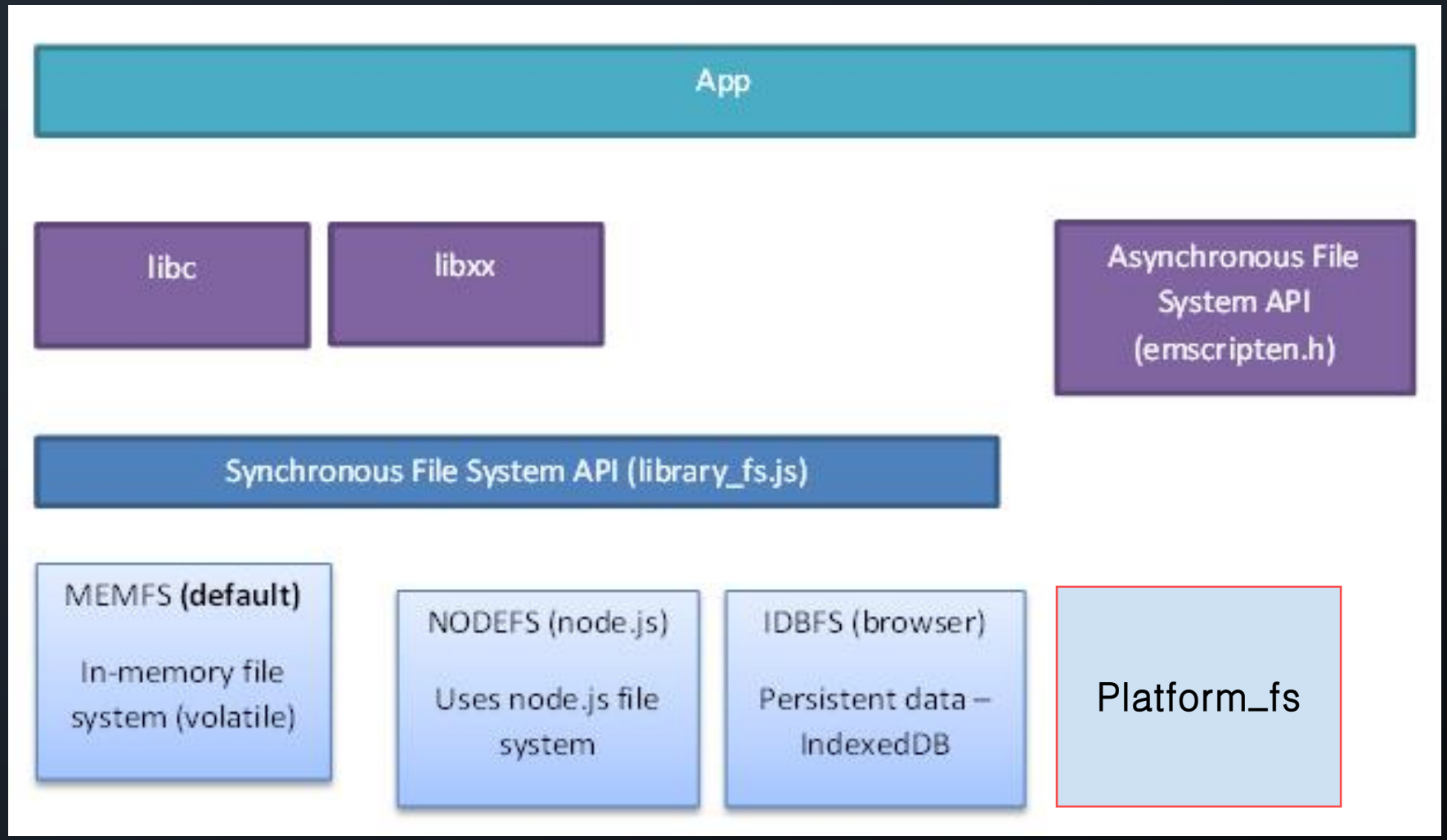



```
readFile(path, opts = {}) {
    opts.flags = opts.flags || {{ { cDefs.O_RDONLY } }};
    opts.encoding = opts.encoding || 'binary';
    if (opts.encoding !== 'utf8' && opts.encoding !== 'binary')
    {
      throw new Error(`Invalid encoding type "${opts.encoding}"`);
    }
    var ret;
    var stream = FS.open(path, opts.flags);
    var stat = FS.stat(path);
    var length = stat.size;
    var buf = new Uint8Array(length);
    FS.read(stream, buf, 0, length, 0);
    if (opts.encoding === 'utf8') {
      ret = UTF8ArrayToString(buf, 0);
    } else if (opts.encoding === 'binary') {
      ret = buf;
    }
    FS.close(stream);
    return ret;
    }
```

https://kripken.github.io/emscripten-site/docs/introducing_emscripten/about_emscripten.html

PART TWO

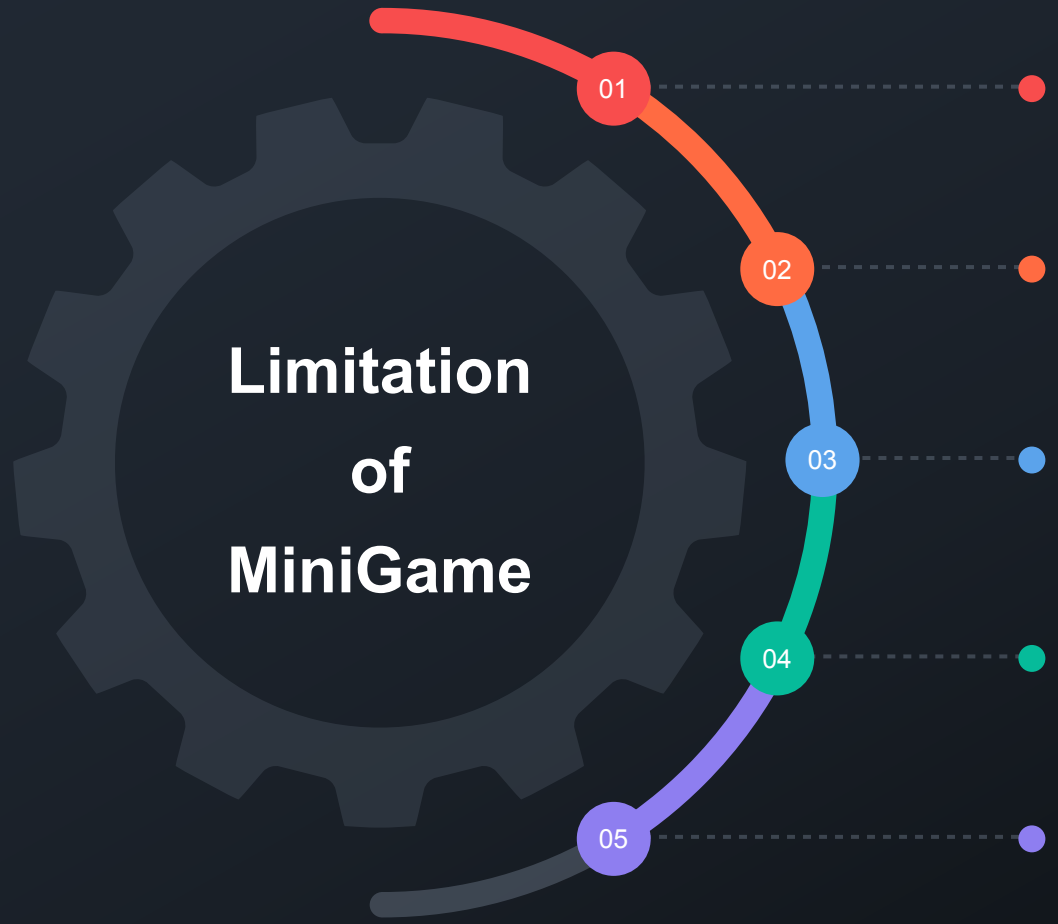
Transform and Optimization



https://emscripten.org/docs/porting/files/file_systems_overview.html

PART TWO

Transform and Optimization



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PART TWO

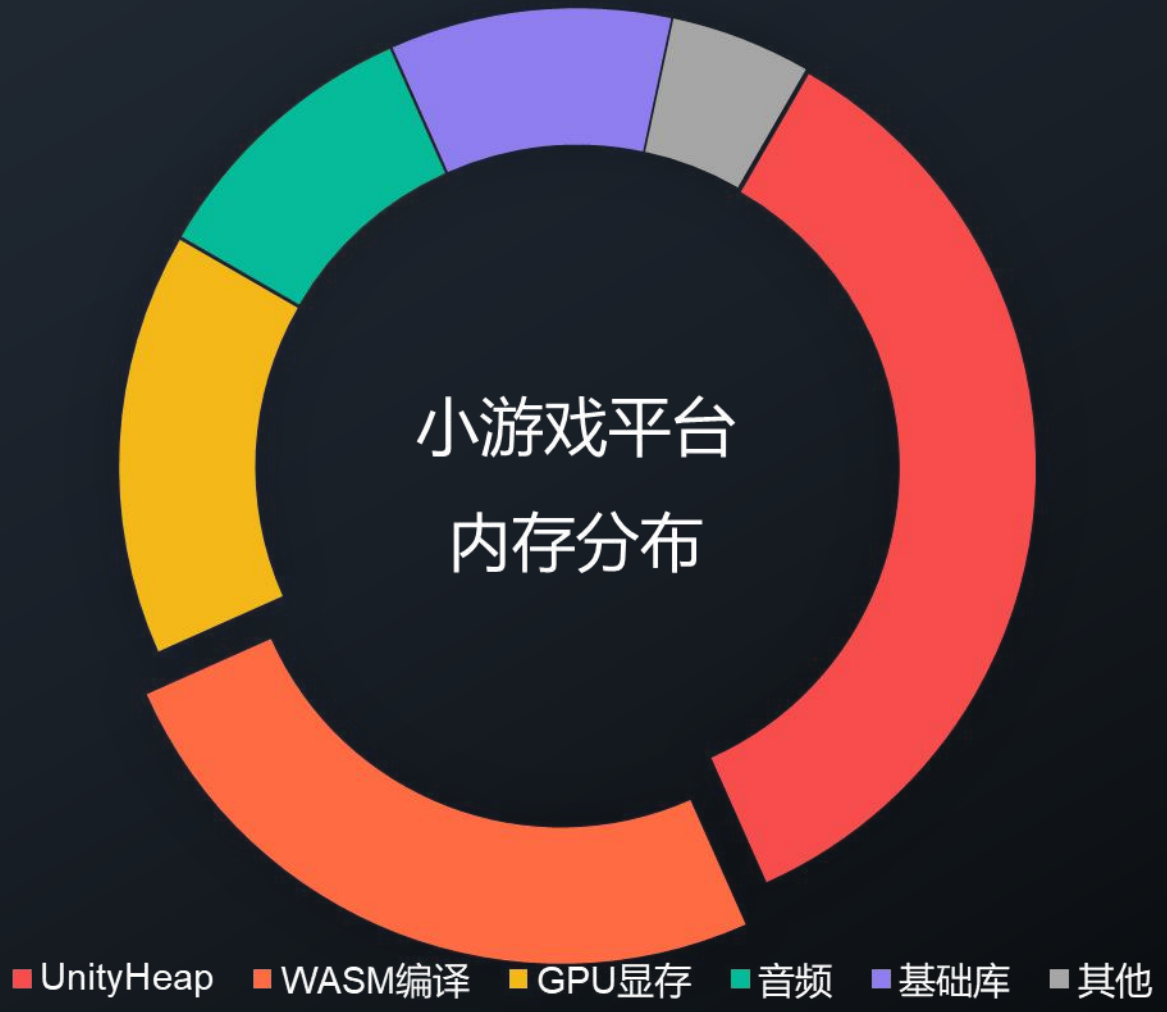
Transform and Optimization

Android: 低档机 < 1.2G, 中高档机 < 1.5G

iOS: 低档机 < 1G, 中高档机 < 1.4G

PART TWO

Transform and Optimization



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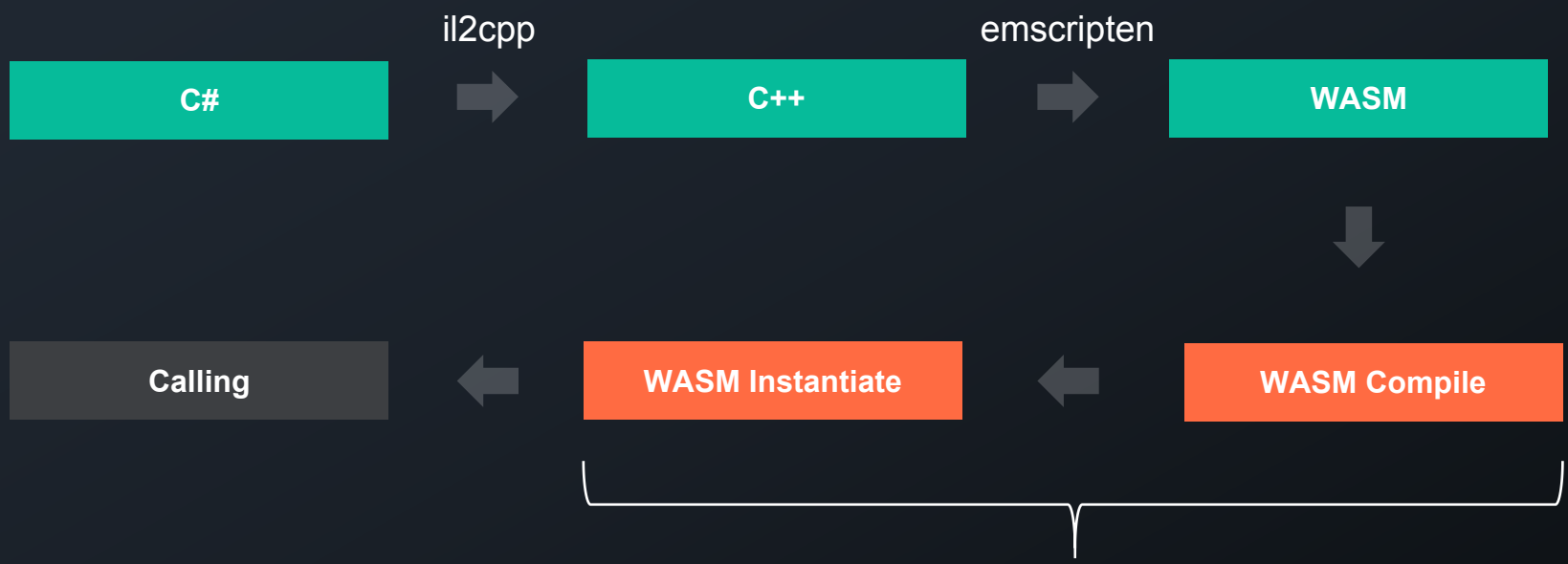


wasm memory ≈ webgl.wasm * 10

Android V8, iOS WebKit, Core Version

e.g.:

webgl.wasm ≈ 90M

wasm memory ≈ 900M

PART TWO

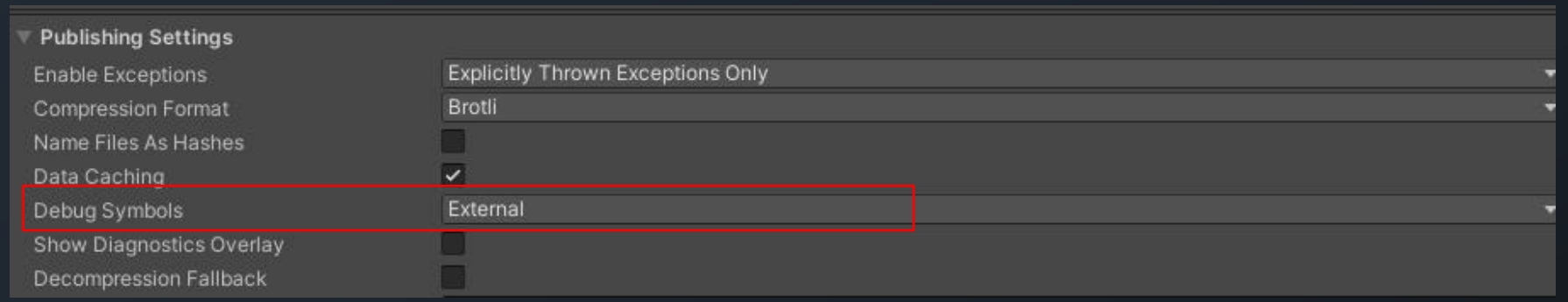
Transform and Optimization

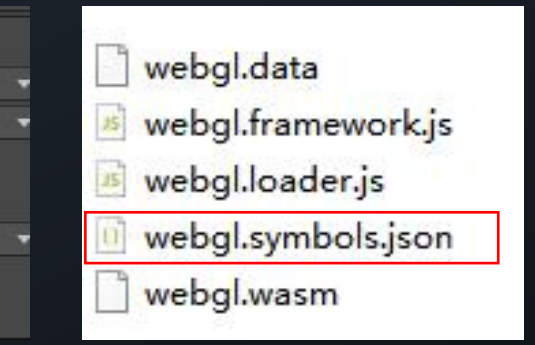
WASM = Engine Code + Unity Package + ThirdPart + GamePlay

- Engine Code — Player Settings / Other Settings / Strip Engine Code
- GamePlay — Player Settings / Other Settings / Managed Stripping Level
- Unity Package — Built-in， In Project
- ThirdPart — Assembly Define Platforms， Remove Unused File
- **C# NameSpace** — e.g. System.Threading
- **Shared Library** — e.g. JSON（unity package + third part + wxsdk）
- **Design Patterns** — Build Settings / Code Optimization : Runtime Speed

PART TWO

Transform and Optimization






```
"130147": "AudioMixer::GetTypeVirtualInternal\\28\\29\\20const",
"130148": "AudioMixer::GetInitialSnapshotIndex\\28\\29",
"130149": "AudioMixer::ClearFloat\\28char\\20const*\\29",
"130150": "AudioMixer::CheckConsistency\\28\\29",
"130151": "AudioMixer::AwakeFromLoad\\28AwakeFromLoadMode\\29",
"130152": "AudioMasterDSPProcessCallback\\28UnityAudioEffectState*\\2c\\20float*\\
"130153": "AudioManager::~AudioManager\\28\\29.1",
"130154": "AudioManager::systemCallback\\28FMOD_SYSTEM*\\2c\\20FMOD_SYSTEM_CALLBAC
"130155": "AudioManager::VirtualRedirectTransfer\\28StreamedBinaryWrite&\\29",
"130156": "AudioManager::VirtualRedirectTransfer\\28StreamedBinaryRead&\\29",
"130157": "AudioManager::VirtualRedirectTransfer\\28SafeBinaryRead&\\29",
"130158": "AudioManager::VirtualRedirectTransfer\\28GenerateTypeTreeTransfer&\\29"
"130159": "AudioManager::Reset\\28\\29",
"130160": "AudioManager::MainThreadCleanup\\28\\29",
```

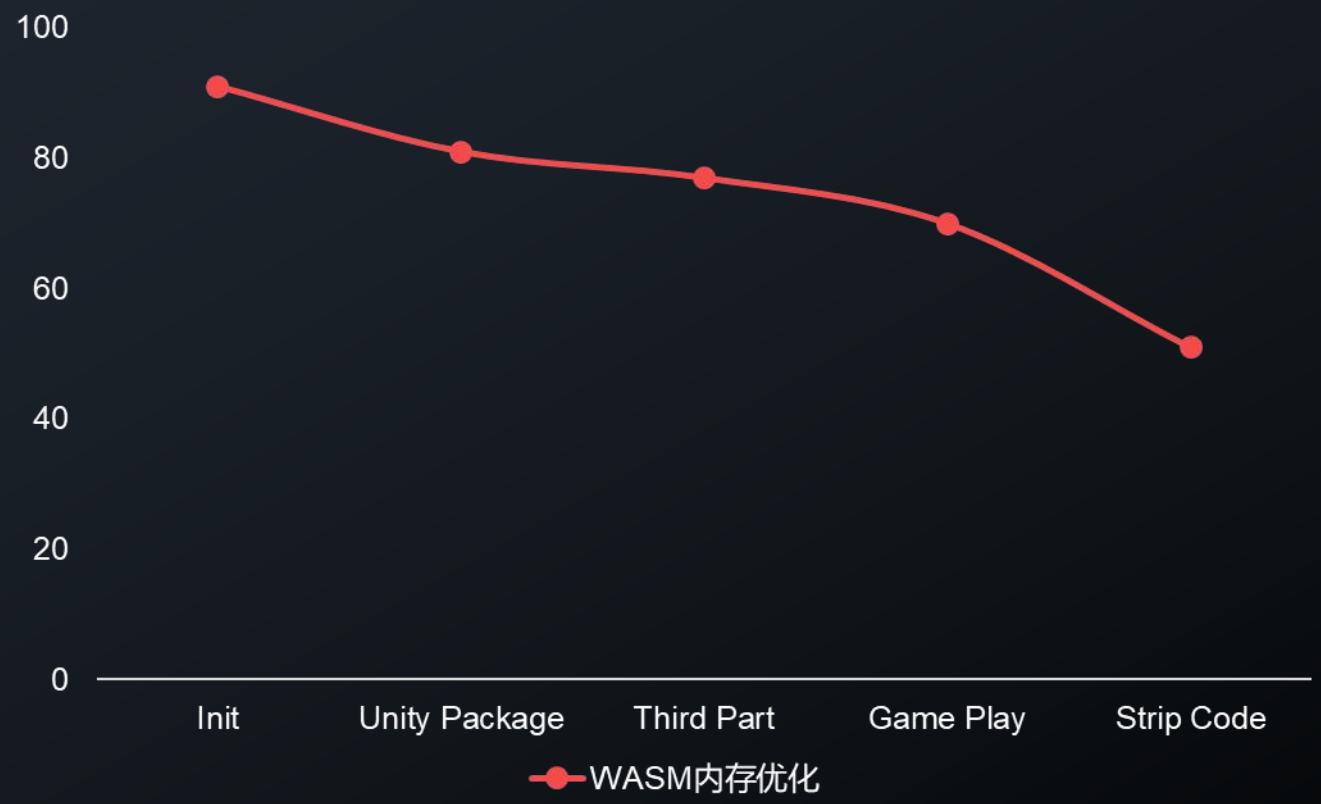
```
UILabel:
  '#Size 大小': 607324
  '#Size 在 wasm 文件中比例': 0.11%
  '#Size 在 所选目录中比例': 0.18%
  '#该类包含的wasm函数index list size': 102
  '#该类包含的wasm函数index list':
```

PART TWO

Transform and Optimization

webgl.wasm：≈90M ~ 51M

节省内存：≈400M



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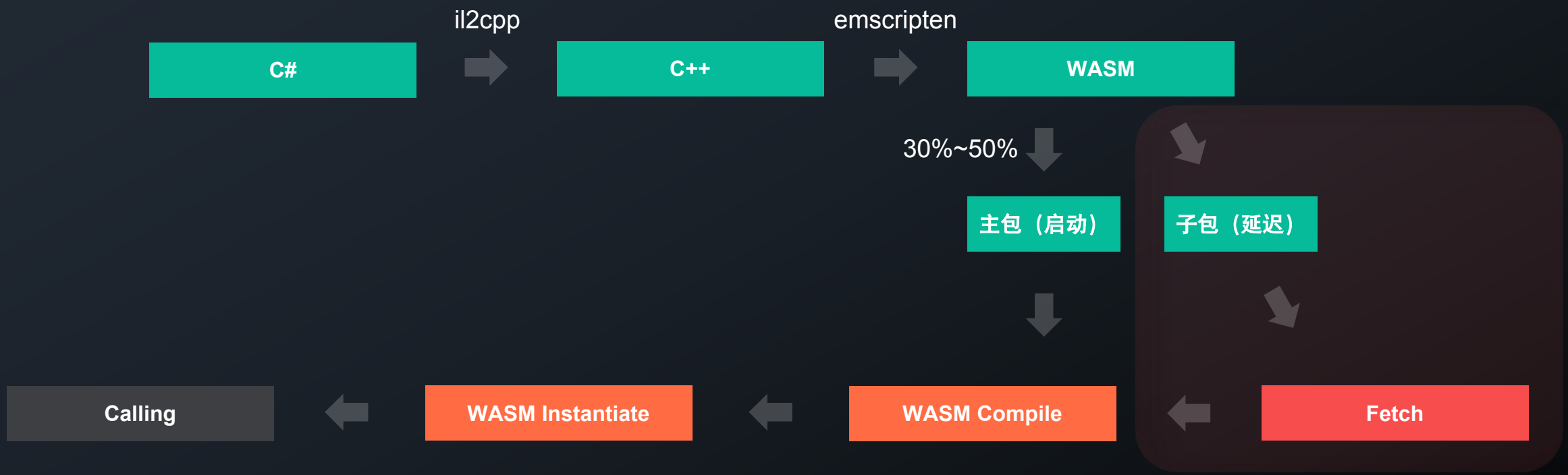

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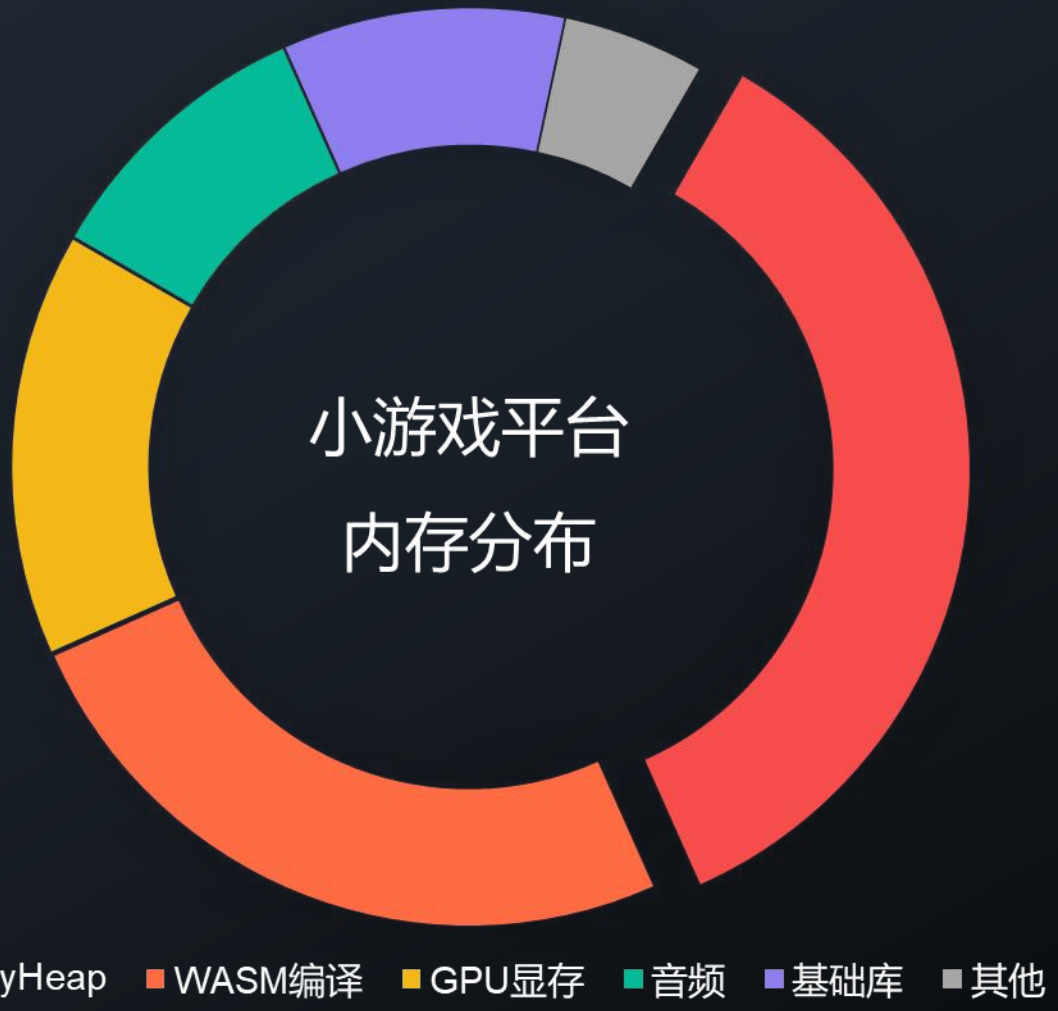
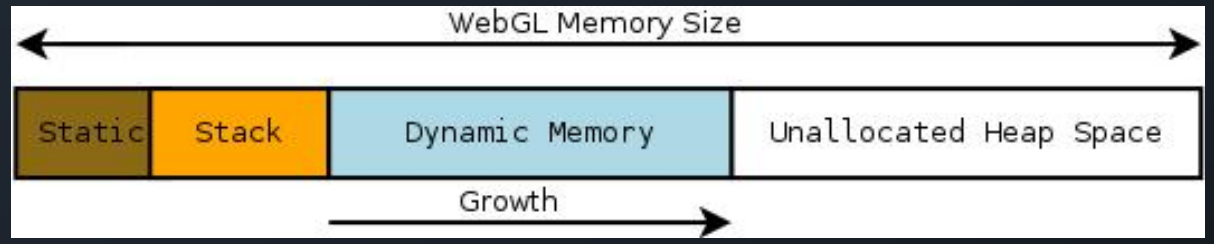


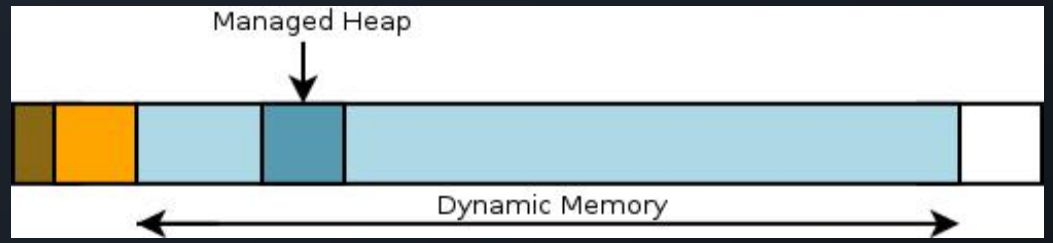
PART TWO

Transform and Optimization

UnityHeap = Static + Stack + **Dynamic** + Unallocted

Dynamic = MonoHeap + NativeReserverd + 原生插件内存





PART TWO

Transform and Optimization

UnityHeap Memory On WebGL

- Buffer Array，From Browser JS VM Heap

PART TWO

Transform and Optimization

PlayerSettings

微信小游戏转换面板

New Memory ≈ Initial Memory Size * 120%

Memory Spikes ≈ Initial Memory Size + New Memory

Memory size alignment multiples of 16

e.g:

- Initial Memory Size = 600M => 608M
- **Memory Spikes** ≈ 608M + 608M * 120%

建议值:

超休闲游戏: 256

中度游戏(模拟经营、卡牌成长): 496

重度游戏(SLG,MMO): 768

预留内存 = Max(Dynamic Memory) + 100M(+-)

PART TWO

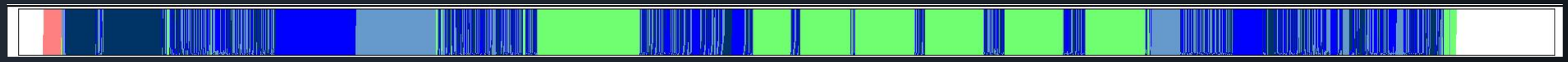
Transform and Optimization

UnityHeap Memory On WebGL

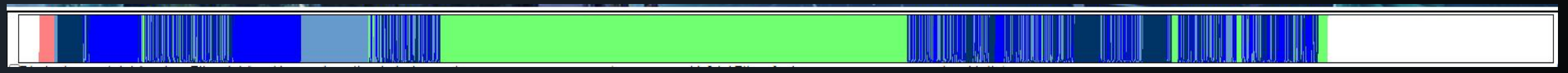
- Buffer Array，From Browser JS VM Heap
- Managed Heap allocated from the Unity Heap，never returned to the os system
- Managed Heap memory can only grow

PART TWO

Transform and Optimization



```
void ManagedAlloc(int sizeInMB)
{
        byte[] buf = new byte[sizeInMB * 1024 * 1024];
        buf = null;
}
```



PART TWO

Transform and Optimization

Garbage Collection On WebGL

1. in frame，no GC
2. GC.Collect() has no effect
3. frame end，minor GC
4. scene load，full GC

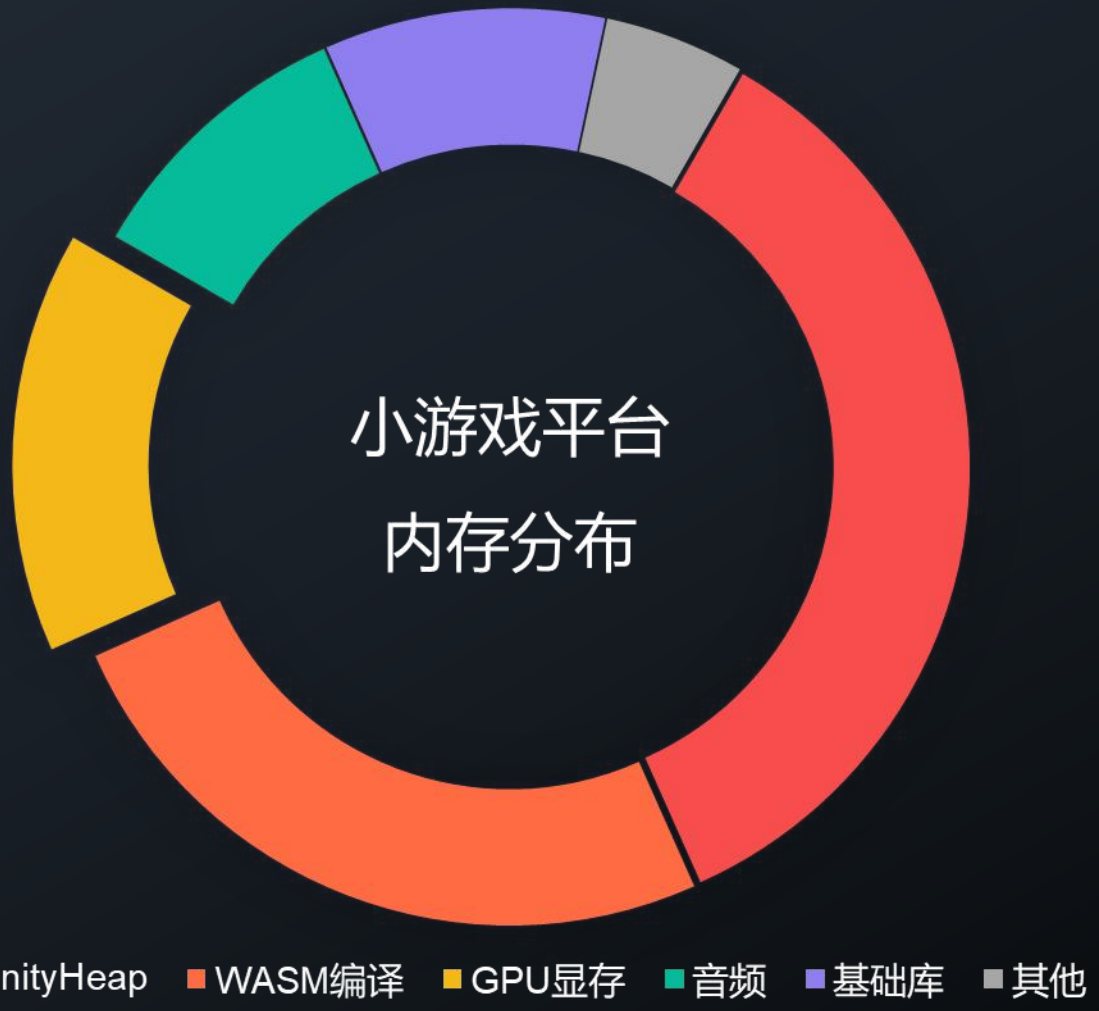
PART TWO

Transform and Optimization

- reasonable unityheap memory，no copy array buffer
- avoid memory fragment：managed memory，obj cache，boxing
- avoid big memory in frame：config file，assetbundle / assets、file system
- delegate、anonymous lambda、closure、coroutine、LINQ、reflection etc.

PART TWO

Transform and Optimization



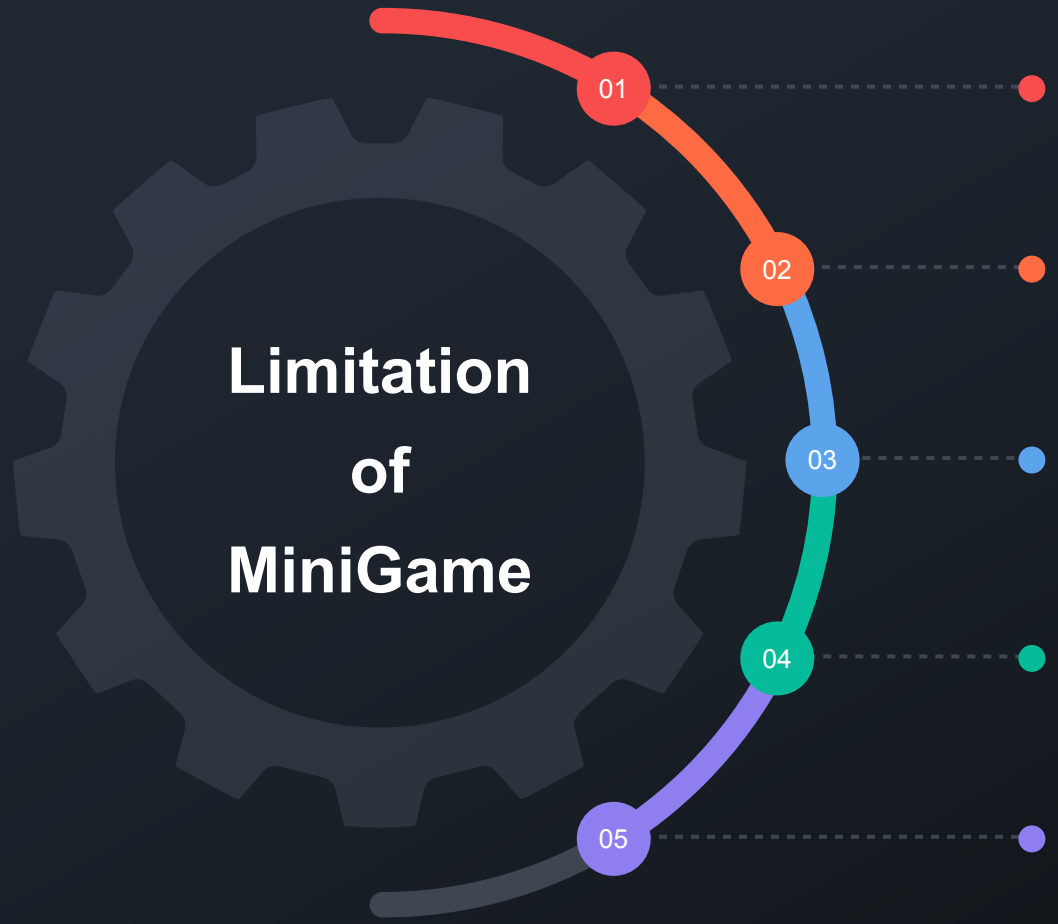
PART TWO

Transform and Optimization

- Support for ASTC on WebGL in Unity 2021+
- iOSHighPerformance+ ≈ 100M

PART TWO

Transform and Optimization



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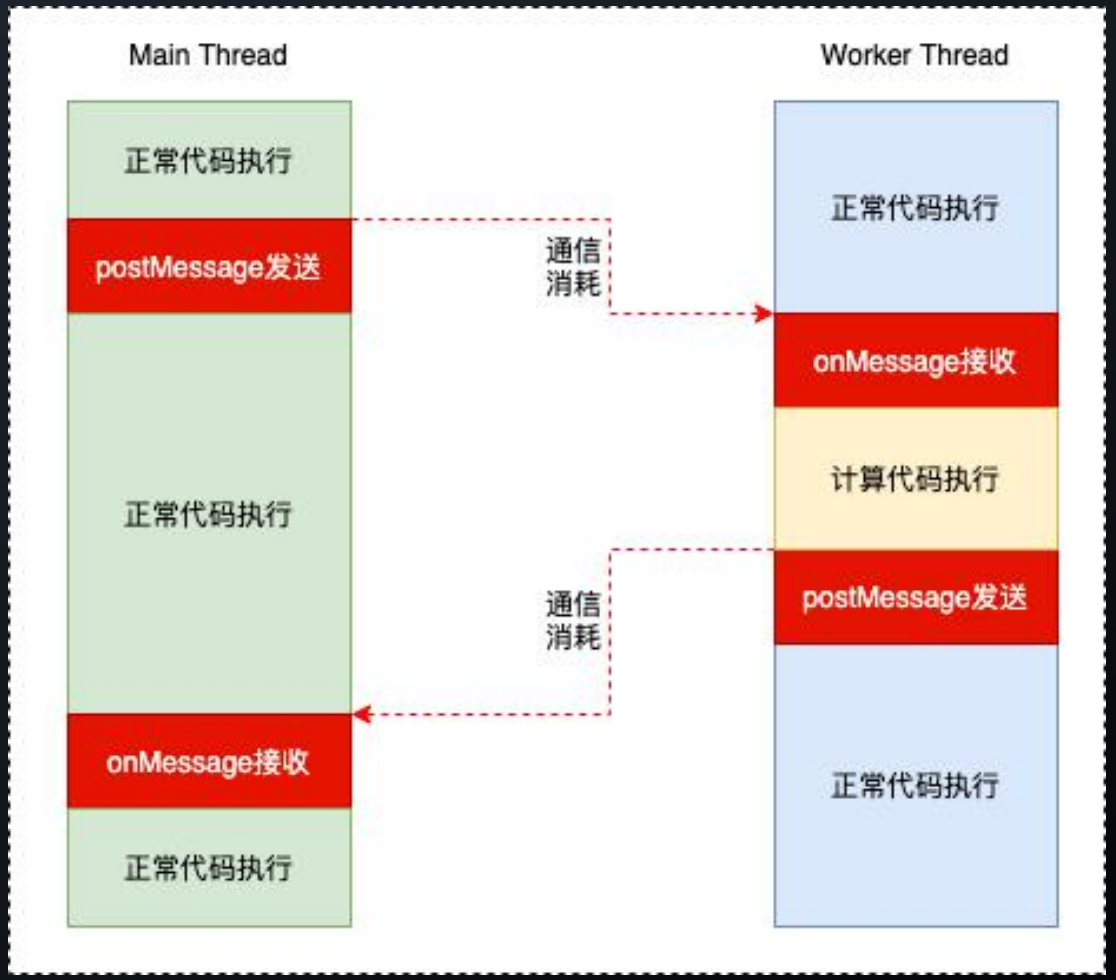
PART TWO

Transform and Optimization

No Multi-thread Support

Woker 提升的性能 = 并行提升的性能 – 通信消耗的性能



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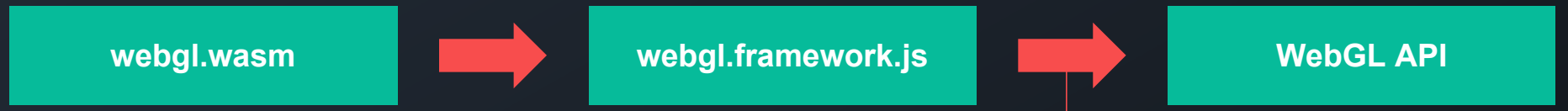


more GL function call, more overhead

SetPassCall + DrawCall

```
glBindBuffer(...);
glVertexAttribPointer(...);
glActiveTexture(0);
glBindTexture(GL_TEXTURE_2D, texture1);
glActiveTexture(1);
glBindTexture(GL_TEXTURE_2D, texture2);
glDrawArrays(...);
```

https://emscripten.org/docs/optimizing/Optimizing-WebGL.html

PART TWO

Transform and Optimization

《How Far We've Come – A Characterization Study of Standalone WebAssembly Runtimes》

WebAssembly Runtimes：Wasmtime、WAVM、Wasmer、Wasm3、WAMR

introduce additional overhead，1.59× ~ 9.57x

more memory consumed，1.26× ~ 5.50×

more machine instructions，2.03x ~ 14.61x

branch prediction miss，1.52× ~ 12.64×

cache miss，1.39× ~ 4.6×

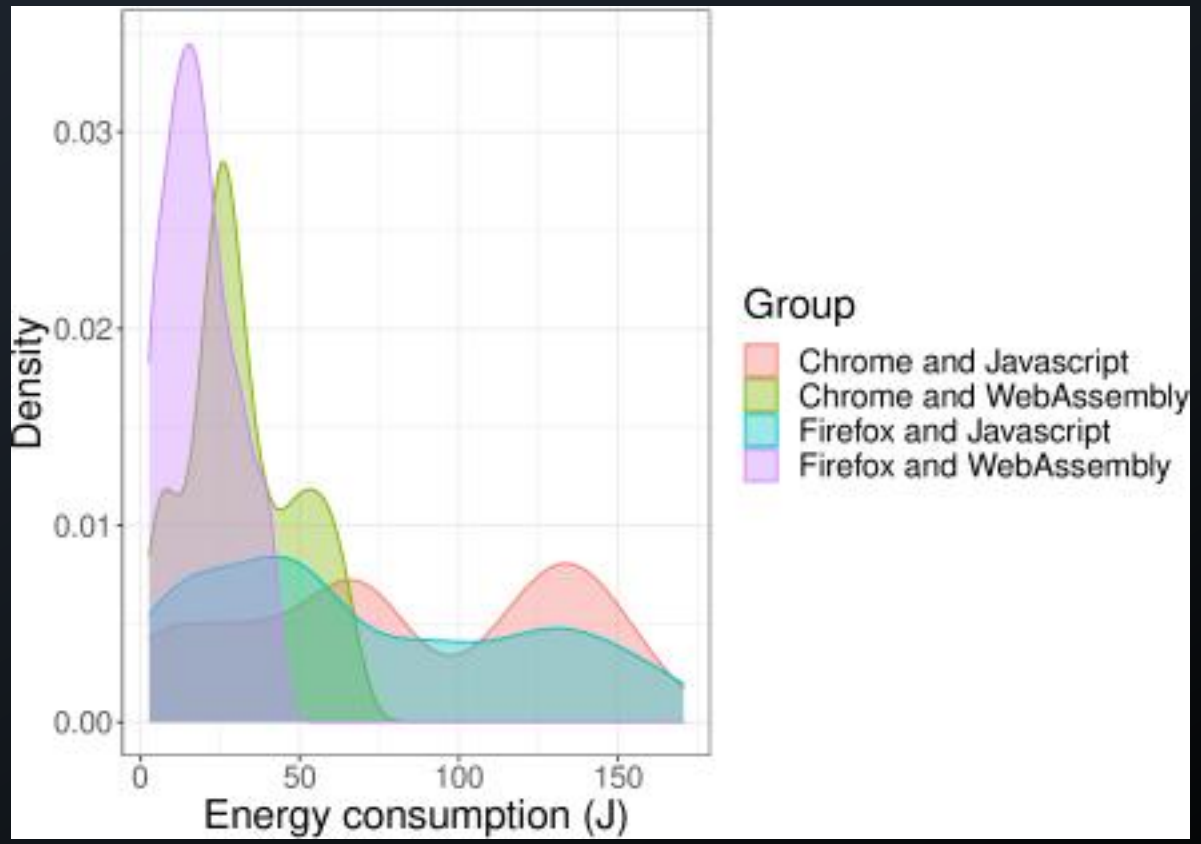
https://cobweb.cs.uga.edu/~wenwen/papers/iiswc2022.pdf

PART TWO

Transform and Optimization

《Comparing the Energy Efficiency of WebAssembly and JavaScript in Web Applications on Android Mobile Devices》

	Energy Consumption (Joules)		
	Both	JavaScript	WebAssembly
Minimum	3.251	3.251	4.039
1st quartile	24.996	35.912	22.226
Median	42.073	72.302	27.913
Mean	56.847	81.785	31.910
3rd quartile	72.280	130.752	46.031
Maximum	164.219	164.219	68.531



https://dl.acm.org/doi/fullHtml/10.1145/3530019.3530034

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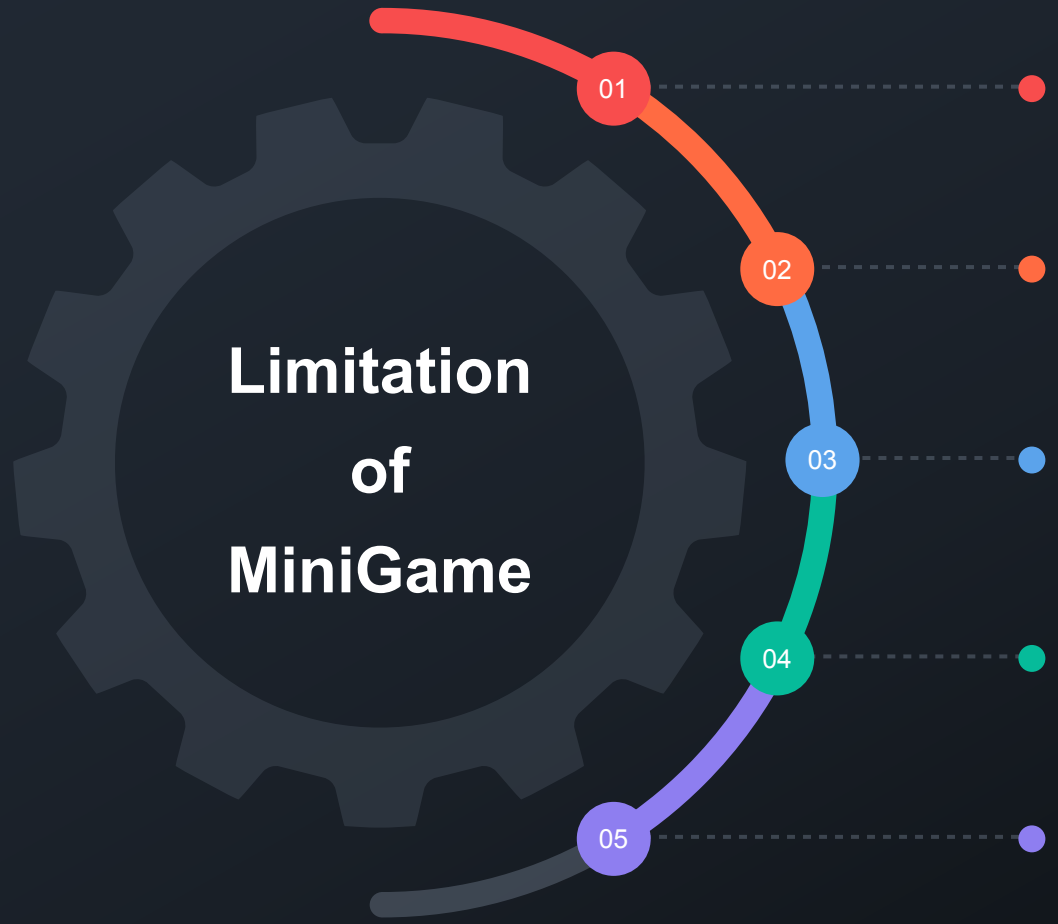

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PART TWO

Transform and Optimization

骁龙660，140角色随机动画

GPU Instancing + VAT

CPU AnimationClip

PART TWO

Transform and Optimization

Linear Color Space

GPU Instancing

SRP Batcher

HDR

Anti-Aliasing

Reflection Probe

Uniform Count & Size

Sampler or Bind Texture > 8

WebGL 1.0 ⟺ OpenGLES2.0

WebGL 2.0 ⟺ OpenGLES3.0

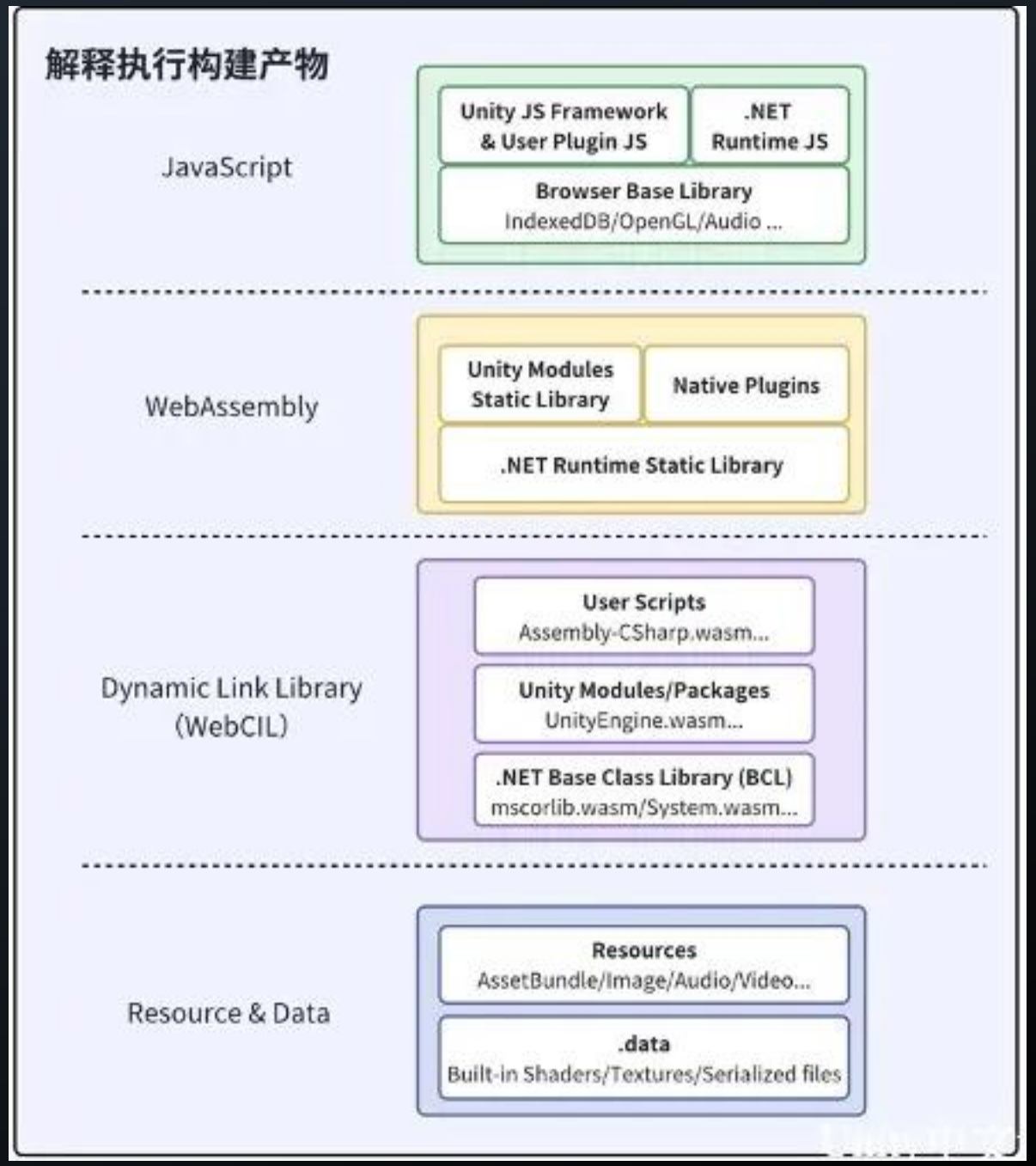
> 98.84%

Tuanjie Engine

PART THREE

Tuanjie Engine

- WASM Memory： Jiterpreter
- Code Hot Patching



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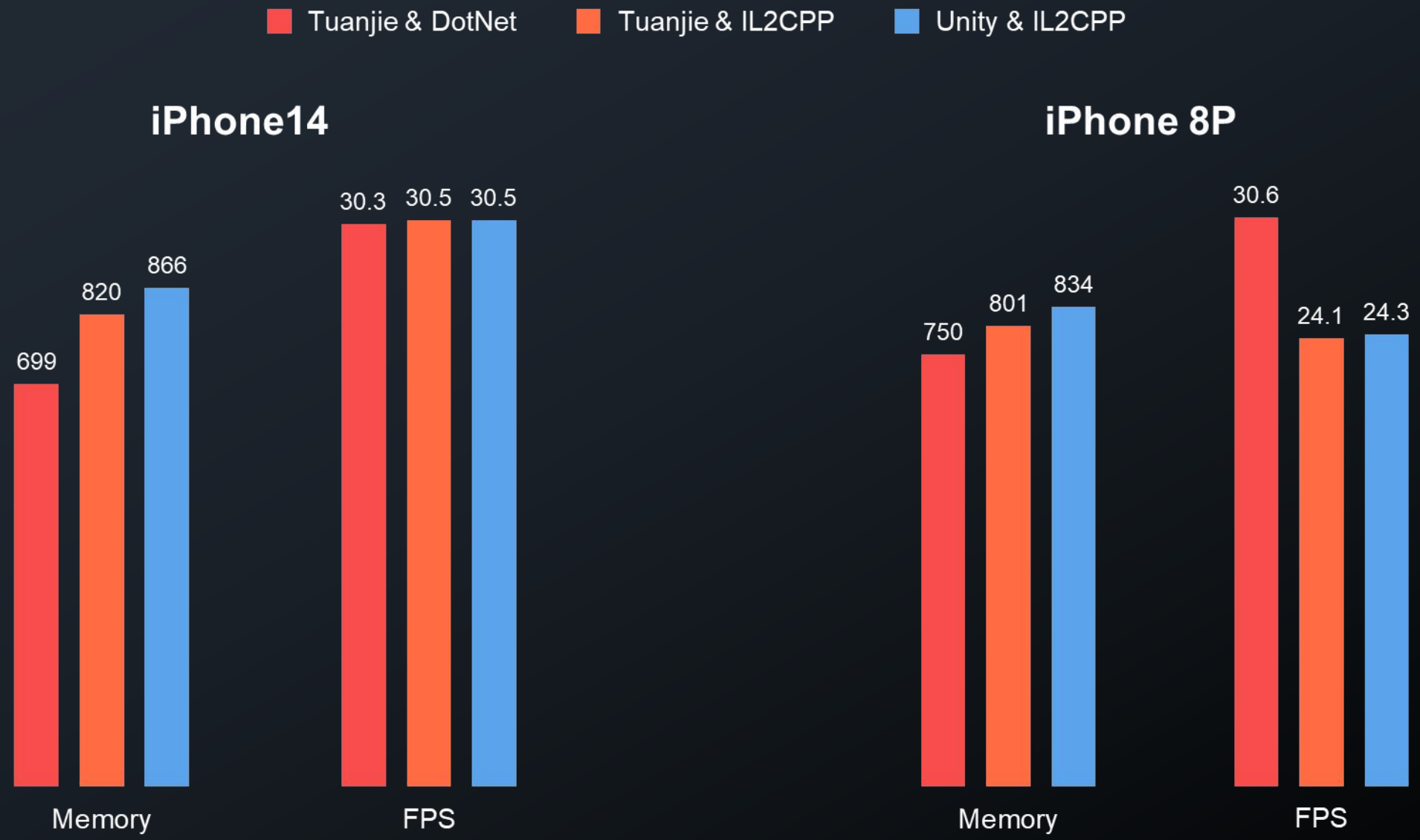

THANK YOU