

Moonlight Blade Rendering Performance Optimization

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游戏开发者大会·中国

GAME DEVELOPERS CONFERENCE CHINA

SHANGHAI INTERNATIONAL CONVENTION CENTER
SHANGHAI, CHINA · OCTOBER 25-27, 2015

Stat	CallCount	IncAvg	IncMax
Whole Draw Time	1.00	22.65 ms	28.51 ms
Wait FrameSync	1.00	2.12 ms	0.98 ms
Before Render Time	1.00	0.95 ms	1.33 ms
Impulse Render Time	1.00	0.13 ms	0.20 ms
Terrain List Parse Time	1.00	0.48 ms	0.70 ms
Mesh List Parse Time	1.00	1.43 ms	2.42 ms
Draw Depth Only	1.00	0.02 ms	0.02 ms
Draw Shadow Depth	1.00	0.82 ms	1.12 ms
Draw Shadow Combine	0.00	0.00 ms	0.00 ms
Draw GBuffer	1.00	4.10 ms	5.90 ms
GBuffer Opaque	1.00	1.98 ms	3.38 ms
GBuffer Terrain	1.00	0.78 ms	1.17 ms
GBuffer SpeedTree	1.00	0.49 ms	1.01 ms
Draw Lighting	1.00	5.82 ms	8.25 ms
Draw Translucent	1.00	4.01 ms	5.59 ms
Draw Particle	0.00	0.00 ms	0.00 ms
Draw Water	1.00	3.76 ms	5.22 ms
Water Refelect	1.00	3.62 ms	5.02 ms
WaterRef List Parse	1.00	2.09 ms	2.71 ms
WaterRef Opaque List Parse	1.00	0.52 ms	0.67 ms
WaterRef Terrain List Parse	1.00	0.16 ms	0.21 ms
Draw Opaque Refelect	1.00	1.27 ms	2.12 ms
Draw Terrain Refelect	1.00	0.20 ms	0.30 ms
SourceCurrentDraw Impostor Refelect	1.00	0.02 ms	0.04 ms
Speed Tree Cull	1.00	0.50 ms	0.65 ms
Draw PostProcess	1.00	0.14 ms	0.51 ms
Draw LightShaft Query	1.00	0.01 ms	0.04 ms
Draw Localligth	1.00	1.21 ms	1.87 ms
Build Localligt List	1.00	0.34 ms	0.44 ms
Present Scene	1.00	1.42 ms	1.19 ms
Draw UI	1.00	0.57 ms	1.12 ms
GetQueryDataTime	0.00	0.00 ms	0.00 ms
RenderQueryTime	1.00	0.26 ms	0.38 ms
Overlay	1.00	4.41 ms	6.53 ms
User 1	2.00	0.02 ms	0.02 ms
User 2	3.00	0.70 ms	0.94 ms
User 3	0.00	0.00 ms	0.00 ms
User 4	0.00	0.00 ms	0.00 ms
User 5	0.00	0.00 ms	0.00 ms

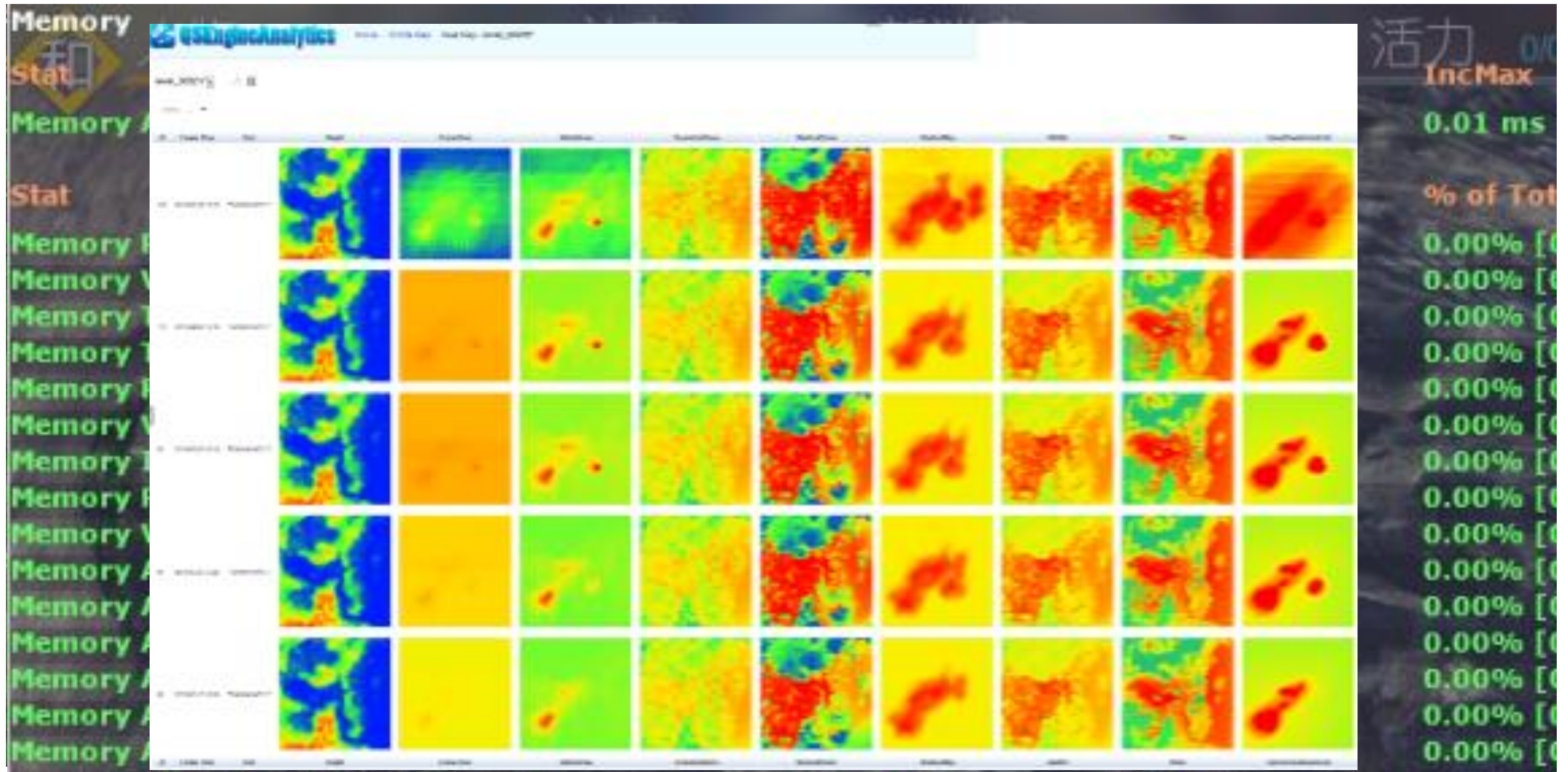
GPUProfileResult	AvgTime	MaxTime
PreRenderLogicWork	0.00 ms	0.00 ms
QSGameRenderGPU	19.23 ms	27.30 ms
ScaleForm	0.17 ms	1.18 ms
QSSceneRenderer_RenderScene	14.43 ms	22.05 ms
RenderImpulse_RenderWater	0.00 ms	0.00 ms
RenderImpulse_RenderGrass	0.01 ms	0.02 ms
LightViewDepthConstruct	0.80 ms	1.70 ms
OpaqueShadow	0.37 ms	0.83 ms
OpaqueShadow	0.11 ms	0.16 ms
OpaqueShadow	0.19 ms	0.70 ms
QSShadowVesturePolicy	0.00 ms	0.00 ms
QSSceneQueryRenderer	1.76 ms	4.63 ms
depthList	0.01 ms	0.02 ms
OcclusionList	0.00 ms	0.01 ms
DepthOnlyPass	0.21 ms	0.29 ms
UIDepth	0.21 ms	0.28 ms
FillParticleTexture	0.01 ms	0.03 ms
GBufferConstruct	4.38 ms	6.49 ms
GBufferHair	0.01 ms	0.01 ms
GBufferOpaque	3.36 ms	5.13 ms
Makeup_Render	0.01 ms	0.01 ms
GBufferImpostor	0.14 ms	0.19 ms
GBufferSpeedTree	0.68 ms	0.92 ms
GBufferTerrain	0.17 ms	0.23 ms
GBufferRoad	0.00 ms	0.00 ms
RenderDecal	0.00 ms	0.00 ms
RenderShadowDecal	0.00 ms	0.00 ms
ScreenSpaceShadowMap	0.49 ms	0.66 ms
DefferredLighting	4.58 ms	8.15 ms
DirectLighting	0.36 ms	0.48 ms
RenderEmissive	0.03 ms	0.04 ms
Locallight	1.76 ms	4.39 ms
SkyAndFog	0.53 ms	0.74 ms
TranslucencyRender	1.89 ms	2.96 ms
QSOuterGlowRenderer	0.00 ms	0.00 ms
ResidueEffect	0.00 ms	0.00 ms
Distortion	0.00 ms	0.00 ms
MotionBlurRenderer	0.00 ms	0.00 ms
QSWeatherParticle	0.00 ms	0.00 ms
LightShaft	0.00 ms	0.00 ms
PostFxDHDR_Render	0.71 ms	0.95 ms
LensFlare	0.00 ms	0.00 ms
OutlinePass	0.00 ms	0.00 ms
OverHeadTranlucentPass	0.00 ms	0.00 ms
PostFxCOLOR	0.00 ms	0.00 ms
QSUIMapCoverRenderer	0.00 ms	0.00 ms
PostFxAA	0.59 ms	0.79 ms
InterlacedRendering	0.00 ms	0.00 ms
EndDrawUIOnRT	0.00 ms	0.00 ms
QSOverlay	0.15 ms	0.73 ms
Present	3.89 ms	6.33 ms

Performance Analysis Tools

- Stat System
- GPU Profiler



Stat System



UProfilerResult	AvgTime	MaxTime
PreRenderLogicWork	0.00 ms	0.00 ms
QSGameRenderGPU	17.55 ms	24.30 ms
ScaleForm	0.02 ms	0.04 ms
QSSceneRenderer_RenderScene	13.96 ms	20.14 ms
RenderImpulse_RenderWater	0.00 ms	0.00 ms
RenderImpulse_RenderGrass	0.01 ms	0.02 ms
LightViewDepthConstruct	1.00 ms	2.39 ms
OpaqueShadow	0.34 ms	0.90 ms
SpeedTreeShadow	0.00 ms	0.00 ms
Render3dTrees	0.00 ms	0.00 ms
OpaqueShadow	0.16 ms	0.31 ms
SpeedTreeShadow	0.04 ms	0.05 ms
Render3dTrees	0.04 ms	0.05 ms
OpaqueShadow	0.14 ms	0.21 ms
SpeedTreeShadow	0.00 ms	0.00 ms
Render3dTrees	0.00 ms	0.00 ms
RenderBillboards	0.00 ms	0.00 ms
QSShadowVesturePolicy	0.22 ms	1.72 ms
SpeedTreeShadow	0.22 ms	1.72 ms
Render3dTrees	0.00 ms	0.00 ms
RenderBillboards	0.22 ms	1.72 ms
QSSceneQueryRenderer	1.68 ms	4.60 ms
depthList	0.01 ms	0.01 ms
OcclusionList	0.00 ms	0.00 ms
DepthOnlyPass	0.24 ms	0.32 ms
UIDepth	0.23 ms	0.31 ms
OverHeadDepthMask	0.00 ms	0.00 ms
FillParticleTexture	0.01 ms	0.02 ms
GBufferConstruct	4.54 ms	7.47 ms
GBufferHair	0.01 ms	0.01 ms
GBufferOpaque	3.38 ms	5.89 ms
GBufferOpaqueInstancing	0.29 ms	0.39 ms
Makeup_Render	0.01 ms	0.01 ms
GBufferImpostor	0.16 ms	0.21 ms
GBufferSpeedTree	0.75 ms	1.01 ms
Render3dTree	0.55 ms	0.74 ms
RenderBillboard	0.20 ms	0.26 ms
RenderGrass	0.00 ms	0.00 ms
GBufferTerrain	0.21 ms	0.39 ms
GBufferRoad	0.00 ms	0.00 ms
RenderDecal	0.00 ms	0.00 ms
RenderShadowDecal	0.02 ms	0.11 ms
ScreenSpaceShadowMap	0.54 ms	0.72 ms
DeferredLighting	4.25 ms	6.75 ms
DirectLighting	0.39 ms	0.53 ms
SkinLighting	0.09 ms	0.12 ms
RenderEmissive	0.10 ms	0.58 ms
LocalLight	1.16 ms	2.79 ms
SkyAndFog	0.57 ms	0.82 ms
TranslucencyRender	2.02 ms	2.83 ms
RenderWaterAndTranslucency	2.02 ms	2.83 ms
TransBeforeWater	0.00 ms	0.00 ms
RestoreRefraction	0.26 ms	0.34 ms
RenderWaterSelf	0.01 ms	0.04 ms
RenderWaterSelf	0.00 ms	0.01 ms
WaterRenderRef	1.65 ms	2.35 ms
RenderWaterSelf	0.02 ms	0.03 ms
RenderWaterSelf	0.00 ms	0.00 ms
TransAfterWater	0.07 ms	0.11 ms
QSOuterGlowRenderer	0.00 ms	0.00 ms
ResidueEffect	0.00 ms	0.00 ms
Distortion	0.00 ms	0.00 ms
MotionBlurRenderer	0.00 ms	0.00 ms
QSWeatherParticle	0.00 ms	0.00 ms
LightShaft	0.00 ms	0.00 ms
PostFxHDR_Render	0.74 ms	1.01 ms
LensFlare	0.00 ms	0.00 ms
OutlinePass	0.00 ms	0.00 ms
OverHeadTranlucentPass	0.00 ms	0.00 ms
PostFxColor	0.00 ms	0.00 ms
QSUIMapCoverRenderer	0.00 ms	0.00 ms
PostFxAA	0.63 ms	0.85 ms
InterlacedRendering	0.00 ms	0.00 ms
EndDrawUIOnRT	0.00 ms	0.00 ms
QSOverlay	0.04 ms	0.06 ms
Present	2.88 ms	4.75 ms

GPU Profiler

- Real-time statistics of each game module's GPU overhead
- Lightweight, has little impact on the game performance
- In-built Profiler, independent of third parties
- Other projects can also use it easily
- UE3 – FarCry has not this feature

Shader instruction optimization case

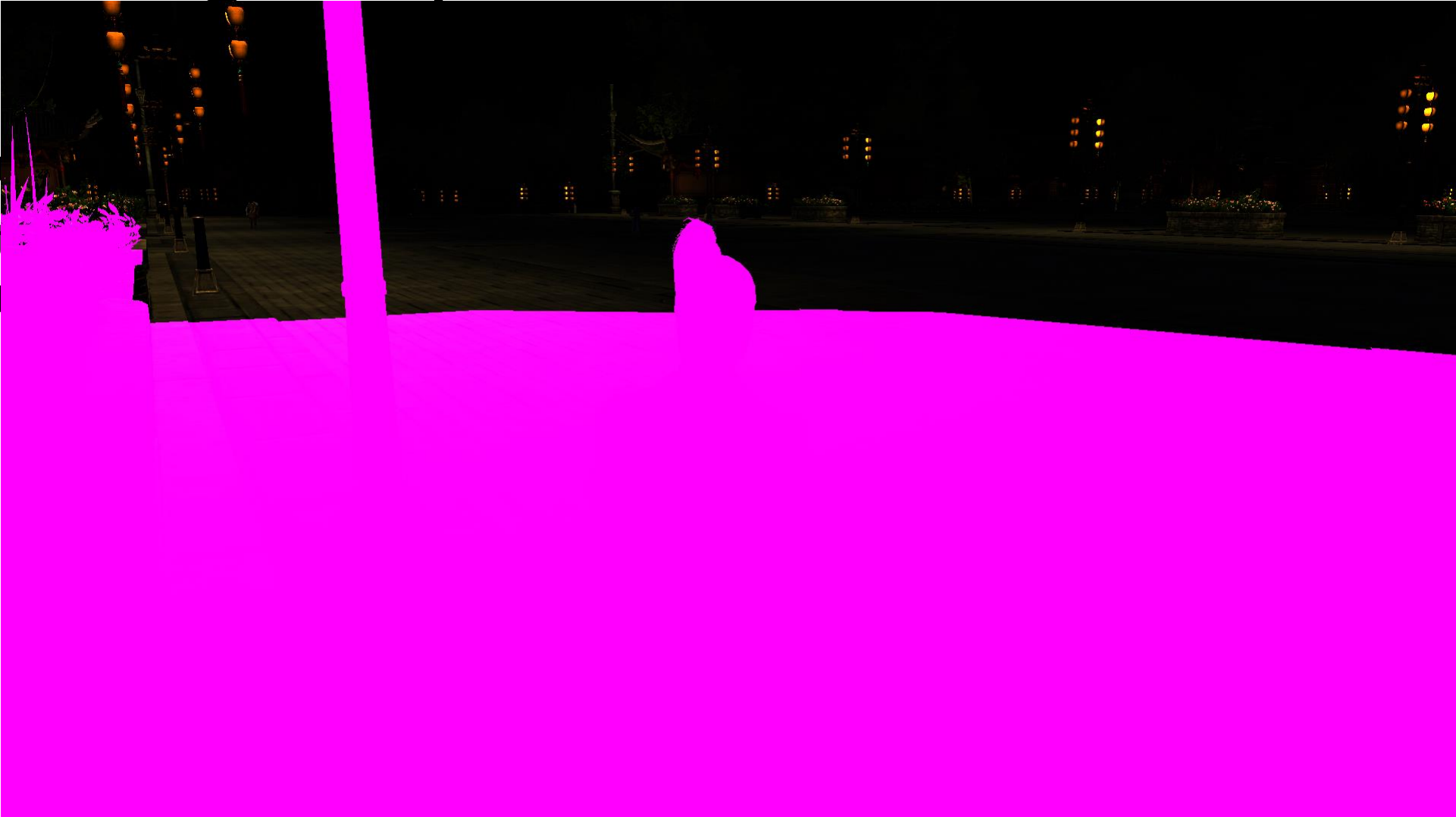


Point light rendering



Point light optimization

- Average
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50%

Water reflection optimization

The screenshot displays a game engine's GPU profile on the left, a game scene in the center, and a game interface on the right. The GPU profile lists various rendering tasks and their execution times. A red arrow points to the 'RenderWater' task, which has an average time of 0.00 ms and a maximum time of 0.00 ms. The game scene shows a character in a blue and white outfit standing in a grassy field with a large rock formation in the background. The game interface on the right includes a map, a quest log, and a task reward section.

GPUProfileResult	AvgTime	MaxTime
PreRenderLogicWork	0.00 ms	0.00 ms
QSGameRenderGPU	8.47 ms	14.49 ms
QSSceneRender_RenderScene	5.76 ms	8.05 ms
RenderImpulse	0.12 ms	0.16 ms
RenderNodes	0.00 ms	0.00 ms
RenderImpulse	0.01 ms	0.01 ms
RenderNodes	0.00 ms	0.00 ms
LightViewDepthConstruct	1.11 ms	2.00 ms
OpaqueShadow	0.30 ms	0.40 ms
SpeedTreeShadow	0.23 ms	0.30 ms
OpaqueShadow	0.62 ms	1.35 ms
SpeedTreeShadow	0.51 ms	1.21 ms
OpaqueShadow	0.16 ms	0.22 ms
SpeedTreeShadow	0.09 ms	0.12 ms
QSShadowVestureMultiFramePolicy	0.00 ms	0.00 ms
SpeedTreeShadow	0.00 ms	0.00 ms
QSSceneQueryRenderer	0.01 ms	0.01 ms
depthList	0.00 ms	0.00 ms
OcclusionList	0.00 ms	0.00 ms
DepthOnlyPass	0.03 ms	0.03 ms
OverHeadDepthMask	0.00 ms	0.00 ms
CalcExposureScale	0.00 ms	0.00 ms
GBufferConstruct	2.12 ms	3.28 ms
GBufferHair	0.00 ms	0.00 ms
GBufferOpaque	0.11 ms	0.43 ms
GBufferSpeedTree	1.17 ms	1.56 ms
GBufferTerrain	0.79 ms	1.06 ms
GBufferRoad	0.00 ms	0.00 ms
RenderDecal	0.00 ms	0.00 ms
RenderShadowDecal	0.03 ms	0.23 ms
ScreenSpaceShadowMap	0.65 ms	0.87 ms
LocalLightShadow	0.00 ms	0.00 ms
DeferredLighting	0.53 ms	0.72 ms
DirectLighting	0.41 ms	0.55 ms
SkinLighting	0.07 ms	0.09 ms
RenderEmissive	0.00 ms	0.00 ms
LocalLight	0.00 ms	0.00 ms
SkyAndFog	0.09 ms	0.12 ms
QSSunRenderer	0.00 ms	0.00 ms
Atmo	0.09 ms	0.12 ms
TranslucencyRender	0.00 ms	0.00 ms
ResidueEffect	0.00 ms	0.00 ms
RenderWater	0.00 ms	0.00 ms
Silhouette	0.00 ms	0.00 ms
FlowingLight	0.00 ms	0.00 ms
FlowingColor	0.00 ms	0.00 ms
Distortion	0.00 ms	0.00 ms
MotionBlurRenderer	0.00 ms	0.00 ms
PostFxDHDR_Render	0.63 ms	1.15 ms
DownScale4	0.08 ms	0.42 ms
Luminance	0.02 ms	0.03 ms
BloomBrightFilter	0.04 ms	0.05 ms
PostFxDHDR_BloomBlur	0.07 ms	0.10 ms
BlendColorGradingRt	0.00 ms	0.00 ms
ToneMappingFinal	0.26 ms	0.35 ms
ReleaseLightShaftRt	0.00 ms	0.00 ms
LensFlare	0.02 ms	0.02 ms
OutlinePass	0.00 ms	0.00 ms
OverHeadTranlucentPass	0.01 ms	0.01 ms
PostFxCColor	0.00 ms	0.00 ms
QSUIMapCoverRenderer	0.00 ms	0.00 ms
PostFxAa	0.65 ms	0.87 ms
EdgeDetect	0.17 ms	0.23 ms
BlendWeight	0.22 ms	0.29 ms
NeighborBlend	0.26 ms	0.35 ms
InterlacedRendering	0.00 ms	0.00 ms
ScaleForm	0.26 ms	0.63 ms
RenderUIBillBoardRT	0.25 ms	0.63 ms
QSOverlay	0.03 ms	0.04 ms
Present	1.77 ms	5.54 ms

杭州：落云滩
非安全区 1433,2141

剧情 见闻

第十四回：飞流翻浪现连环
百里激荡 翻浪水寨

消灭翻浪坞外国水匪
· 翻浪坞水匪 16/20
· 翻浪坞弓手 8/10
· 翻浪坞狂徒 5/5

任务奖励

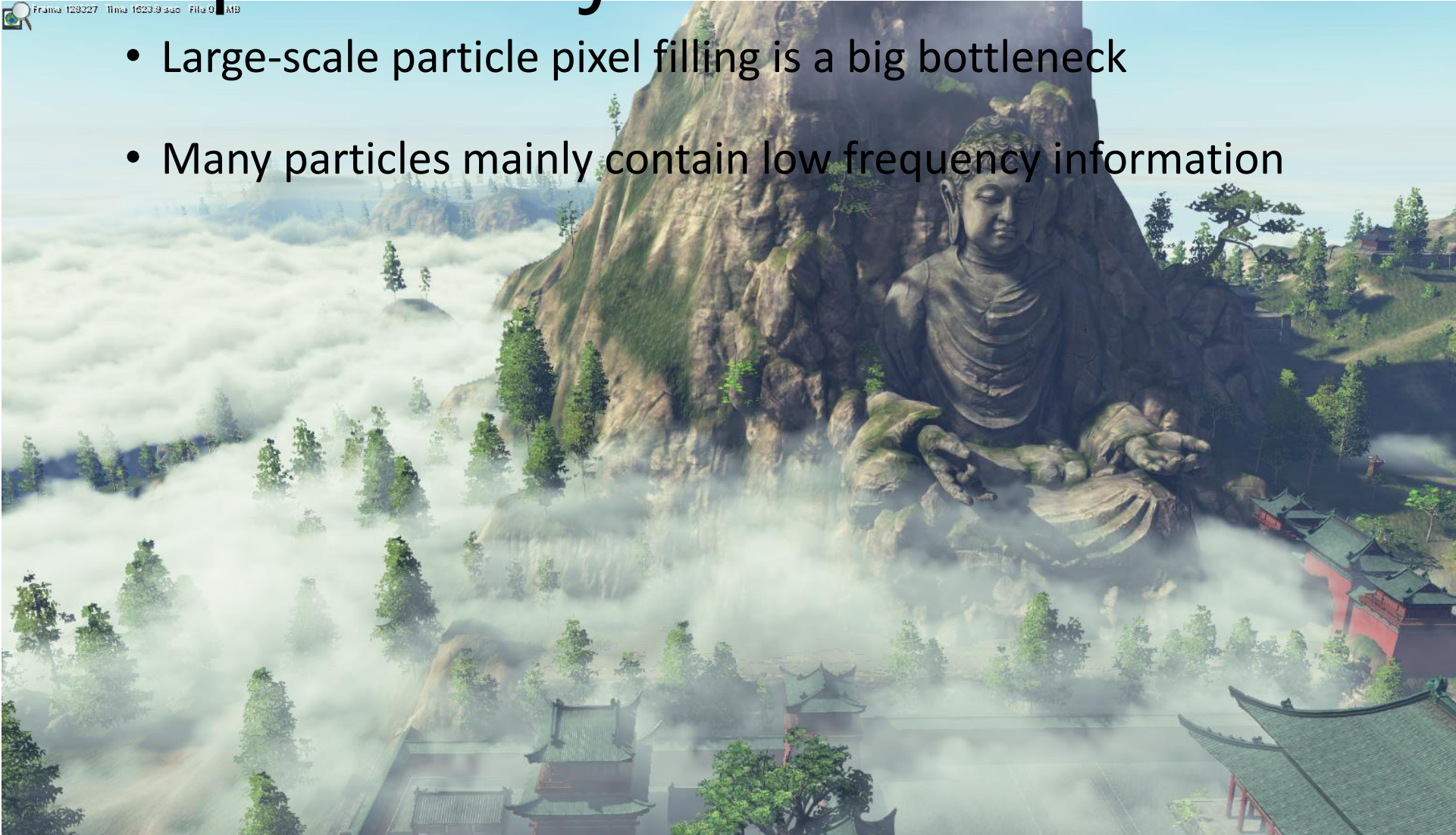
当前 58

Local Reflection



Quarter Buffer rendering of transparent objects

- Large-scale particle pixel filling is a big bottleneck
- Many particles mainly contain low frequency information



Quarter Buffer causes significant aliasing

Full Resolution



Quarter Resolution



Bilateral Filter

- A mag

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- NV C

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- Use N
 - non-e



Sample



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Quarter Buffer Performance Data



Frame: 1233227 Time: 1523.9 sso File: 0.0 MB

VolumeCloud	QuarterDepth	Particles	UpSample	Total
¼Buffer off	0.0ms	2.5ms	0.0ms	2.5ms
¼Buffer on	0.05ms	0.8ms	0.15ms	1.0ms

Save 1.5ms!!!

Memory Optimization

A	B	C	D	E	F
TextureName	TexMem	Width	Height	MipLevels	Format
.\Data\Scene\Texture\MipMapChain.dds	2796344	2048	2048	12	DXT1
Bone	786432	384	128	1	A32B32G32R32F
Bone	786432	384	128	1	A32B32G32R32F
Bone	786432	384	128	1	A32B32G32R32F
.\Data\Scene\Texture\water_rui_007_a.dds	349680	512	512	10	DXT5
data\Effects\WetNormal.dds	131200	512	512	1	DXT1
data\Effects\LightningMask.dds	131200	512	512	1	DXT1
.\Data\Scene\Texture\Distortion02.dds	131200	512	512	1	DXT1
Data\Scene\skybox\moon.dds	65664	256	256	1	DXT5
data\engine\AreaMap33.dds	54578	165	165	1	PF_A8L8
.\Data\Scene\Texture\shadow01.dds	22000	128	128	8	DXT5
.\Data\Scene\Texture\random.bmp	17464	128	128	1	G8
.\Data\Scene\Texture\Caustics_0.dds	11064	128	128	8	DXT1
.\Data\Scene\Texture\Caustics_1.dds	11064	128	128	8	DXT1
.\Data\Scene\Texture\Caustics_2.dds	11064	128	128	8	DXT1
.\Data\Scene\Texture\Caustics_3.dds	11064	128	128	8	DXT1
.\Data\Scene\Texture\Caustics_4.dds	11064	128	128	8	DXT1
.\Data\Scene\Texture\Caustics_5.dds	11064	128	128	8	DXT1
.\Data\Scene\Texture\Caustics_6.dds	11064	128	128	8	DXT1
.\Data\Scene\Texture\Caustics_7.dds	11064	128	128	8	DXT1

RenderTarget allocation

- Use Pool to allocate
 - Share RenderTarget
 - Manage RenderTarget lifecycle
 - Track RenderTarget allocation by name
 - GC

7e3 Buffer

- A2
- Th
- 0.0

With pre-exposed color

20MB VM Saved

of



Visibility Optimization

- Use Tag Visibility Test to greatly improve the efficiency of Visibility Test (by nearly 4 times)
- Use Tag's Software Occlusion Culling , to clip invisible objects according to terrain, and greatly improve the performance
- Integrate the bounding box function within object to greatly improve the performance of home city
- Speed Tree uses Tag Occlusion Culling to improve the performance

Occlusion Debug View



Test results of Jiuhua area without Occlusion



Test results of Jiuhua area with Occlusion



Jiuhua Occlusion Culling Debug View



Jiuhua data comparison

Test Conditions	Culling Total	Terrain List Parse	Mesh List Parse	Draw GBuffer	Total CPU	CPU Saved	
Occlusion Culling off	0.29ms	0.68ms	0.26ms	2.35ms	16.10ms	0	
Occlusion Culling on	0.76ms	0.24ms	0.05ms	0.99ms	14.53ms	1.57ms	
Test Conditions	Triangles Total	Triangles Terrain	Triangles Static Mesh	Triangles Speed Tree	Triangles Saved	GPU Total	GPU Saved
Occlusion Culling off	1132884	129040	438958	518486	0	10.71ms	0
Occlusion Culling on	515151	71968	193032	203795	617733	9.2ms	1.51ms
Test Conditions	DP Total	DP Terrain	DP Static Mesh	DP Speed Tree	DP Saved		
Occlusion Culling off	1198	430	341	105	0		
Occlusion Culling on	608	123	88	83	590		

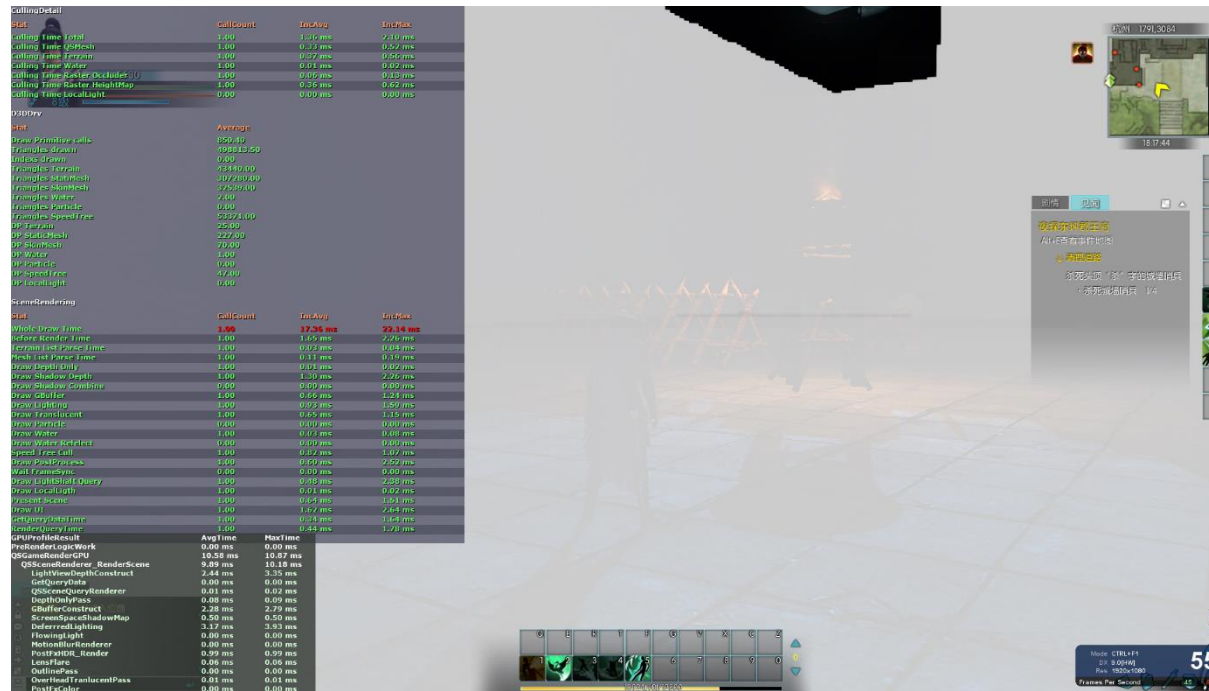
Test results of Hangzhou home city without Occlusion Culling



Test results of Hangzhou home city with Occlusion Culling



Hangzhou home city Occlusion Culling Debug View



Hangzhou home city data comparison

Test Conditions	Culling Total	Terrain List Parse	Mesh List Parse	Draw GBuffer	Total CPU	CPU Saved	
Occlusion Culling off	0.51ms	0.61ms	0.78ms	3.53ms	21.91ms	0	
Occlusion Culling on	1.35ms	0.03ms	0.10ms	0.59ms	16.50ms	5.41ms	
Test Conditions	Triangles Total	Triangles Terrain	Triangles Static Mesh	Triangles Speed Tree	Triangles Saved	GPU Total	GPU Saved
Occlusion Culling off	1546871	102128	952971	239556	0	13.92ms	0
Occlusion Culling on	408263	33536	259931	41463	1138608	9.83ms	4.09ms
Test Conditions	DP Total	DP Terrain	DP Static Mesh	DP Speed Tree	DP Saved		
Occlusion Culling off	2225	417	832	77	0		
Occlusion Culling on	764	23	192	43	1461		

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Test Conditions	Triangles Total	Triangles Terrain	Triangles Static Mesh	Triangles Speed Tree	Triangles Saved	GPU Total	GPU Saved
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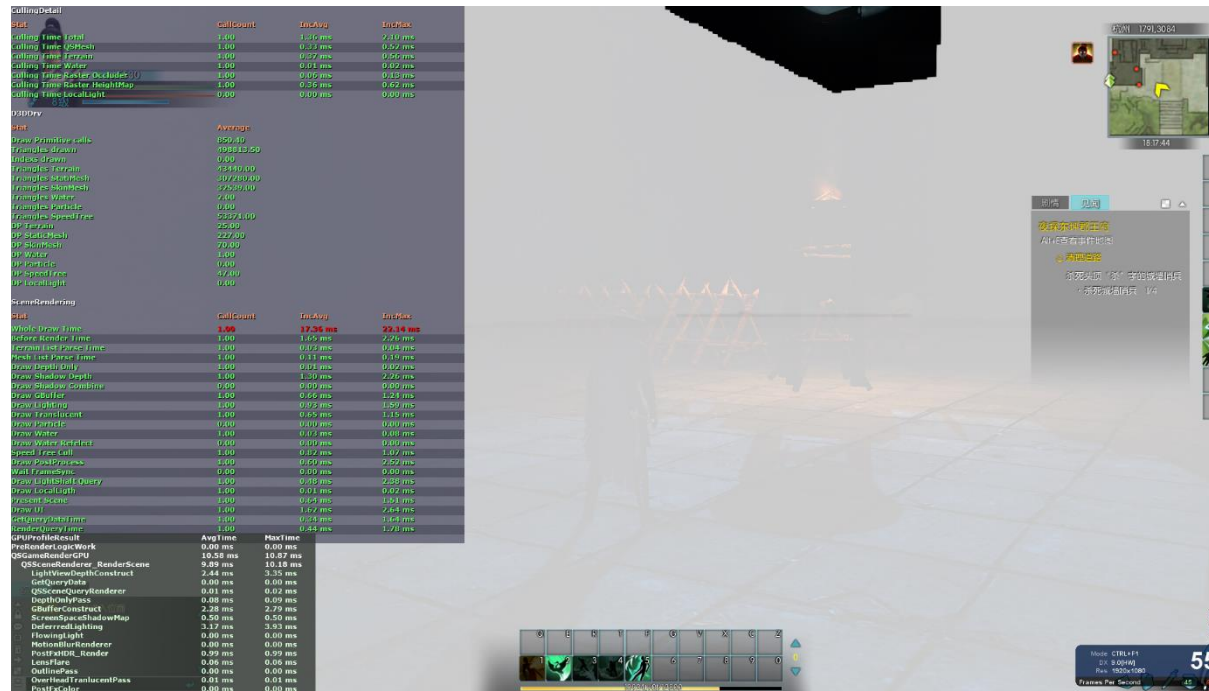
Test results of Hangzhou home city without Occlusion Culling



Test results of Hangzhou home city with Occlusion Culling



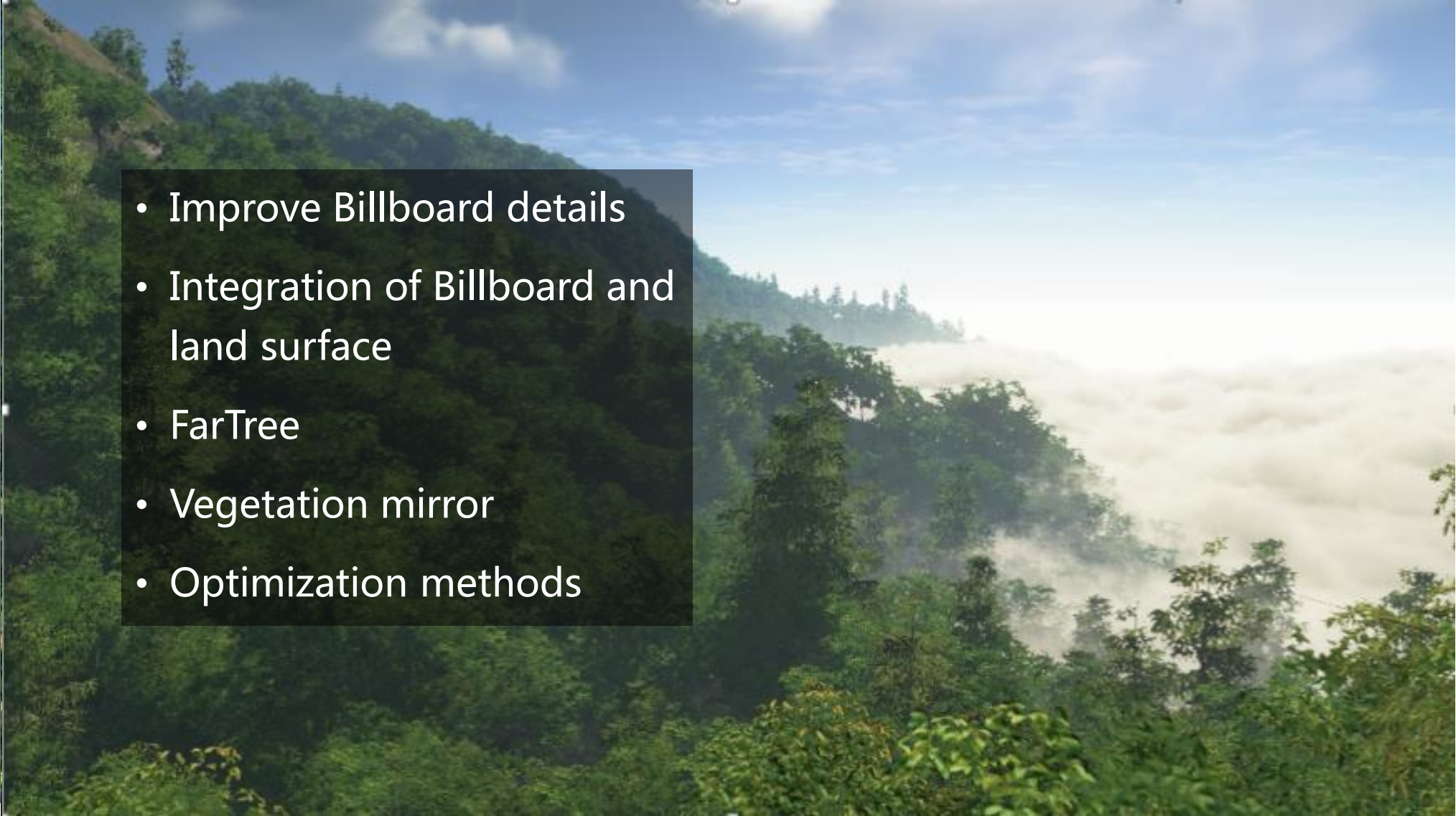
Hangzhou home city Occlusion Culling Debug View



Hangzhou home city data comparison

Test Conditions	Culling Total	Terrain List Parse	Mesh List Parse	Draw GBuffer	Total CPU	CPU Saved	
Occlusion Culling off	0.51ms	0.61ms	0.78ms	3.53ms	21.91ms	0	
Occlusion Culling on	1.35ms	0.03ms	0.10ms	0.59ms	16.50ms	5.41ms	
Test Conditions	Triangles Total	Triangles Terrain	Triangles Static Mesh	Triangles Speed Tree	Triangles Saved	GPU Total	GPU Saved
Occlusion Culling off	1546871	102128	952971	239556	0	13.92ms	0
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Occlusion Culling off	2225	417	832	77	0		
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Vegetation

- 
- Improve Billboard details
 - Integration of Billboard and land surface
 - FarTree
 - Vegetation mirror
 - Optimization methods

Improve Billboard details



Integration of Billboard and land surface



FarTree



Vegetation mirror



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Vegetation performance optimization

- Shadow Optimization
- CPU Optimization
- Data Optimization
- Occlusion Culling
- Memory Optimization

Shadow Optimization

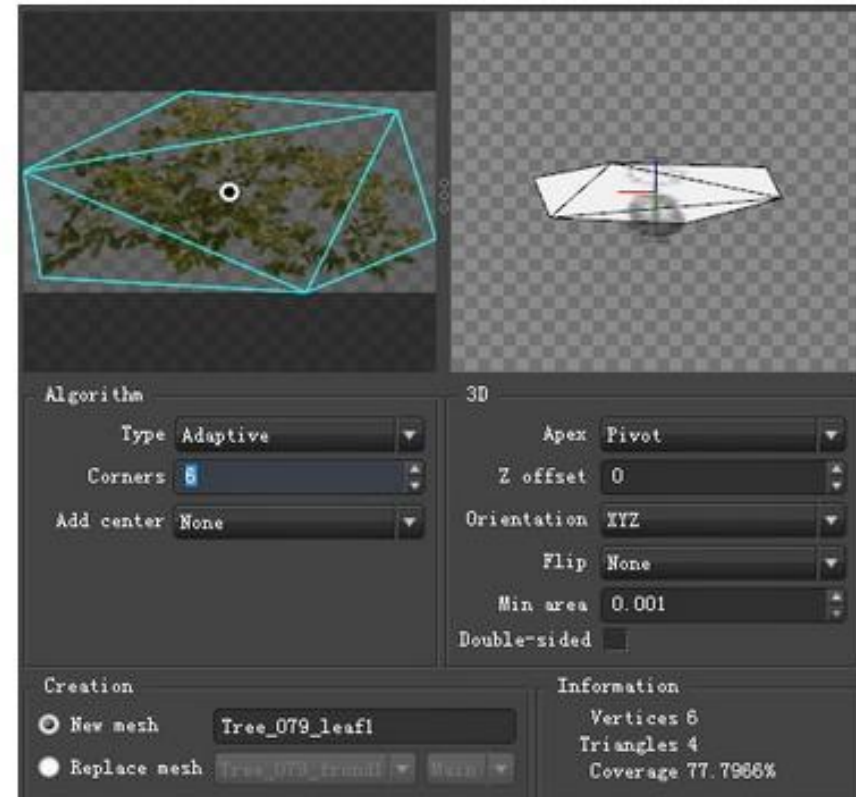
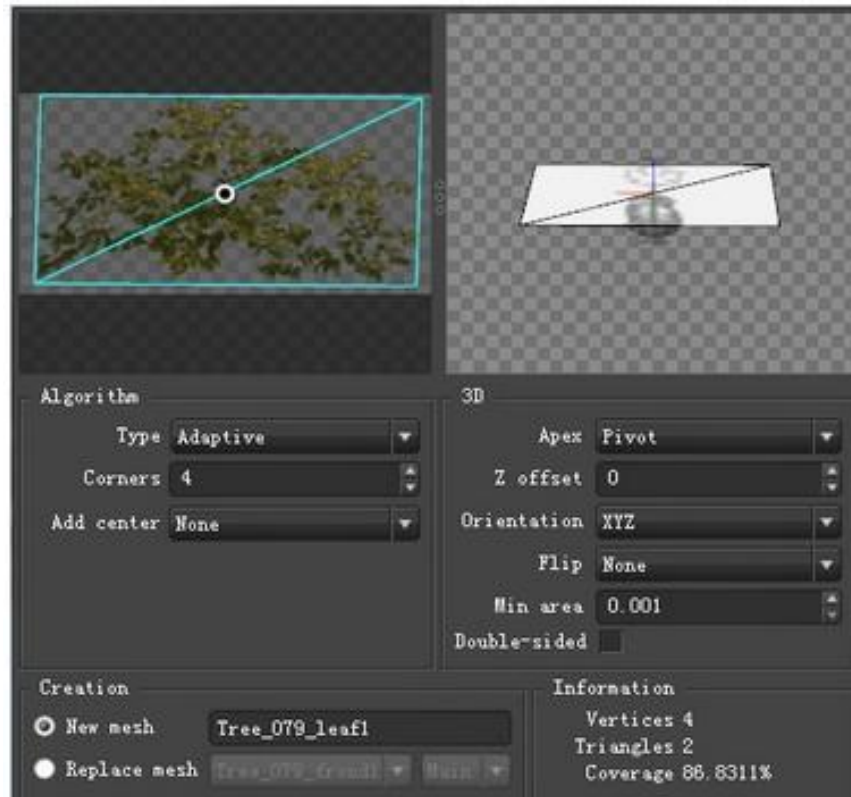
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CPU Optimization

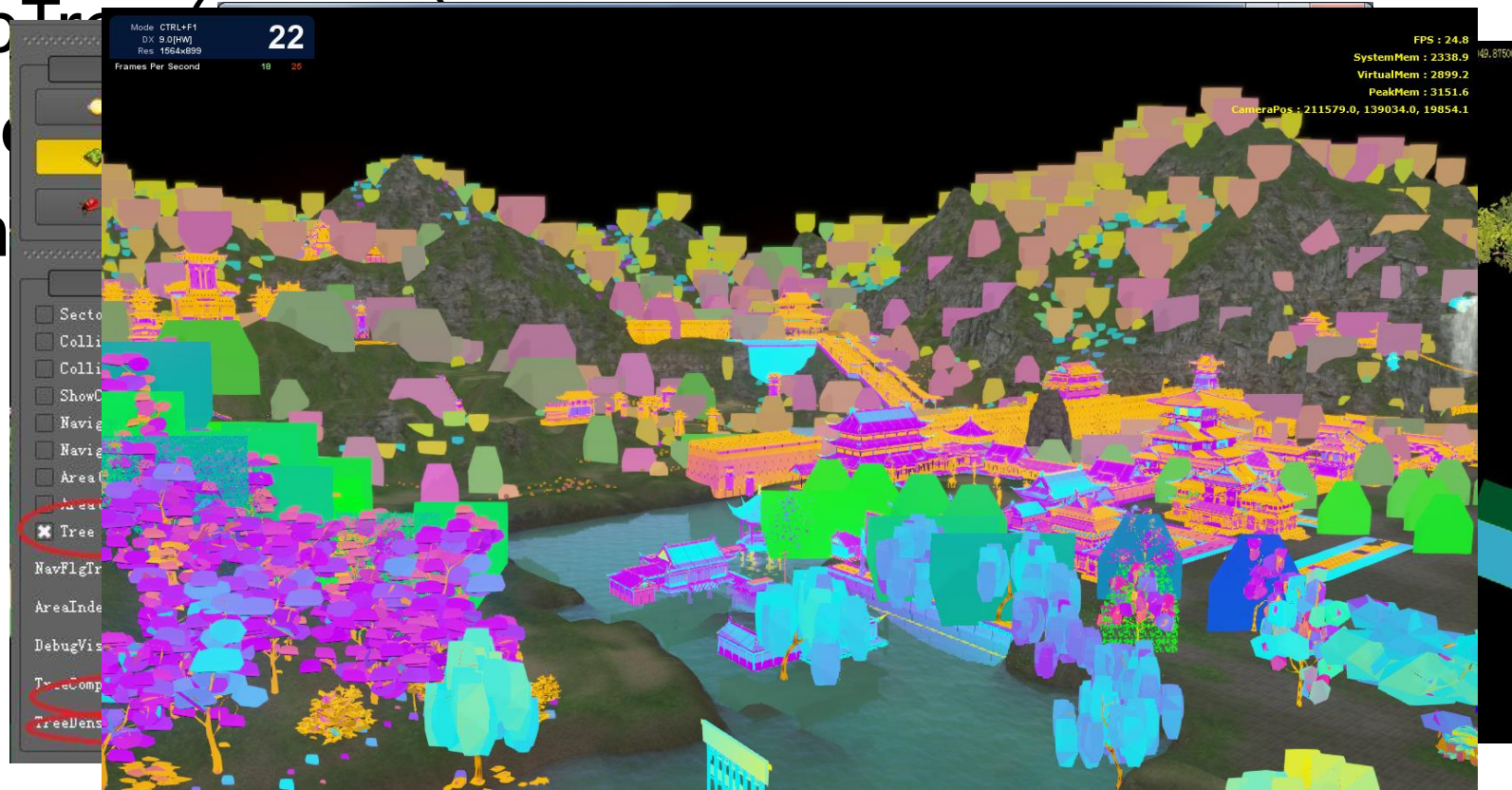
- FreeAlloc and quick allocation releasing tree nodes significantly improved the fluency
- Cache BuildInstanBuffer time has been optimized and shorten from 7-8ms to 0.5ms
- Enabled compiler SSE optimization

Vegetation Resource Optimization

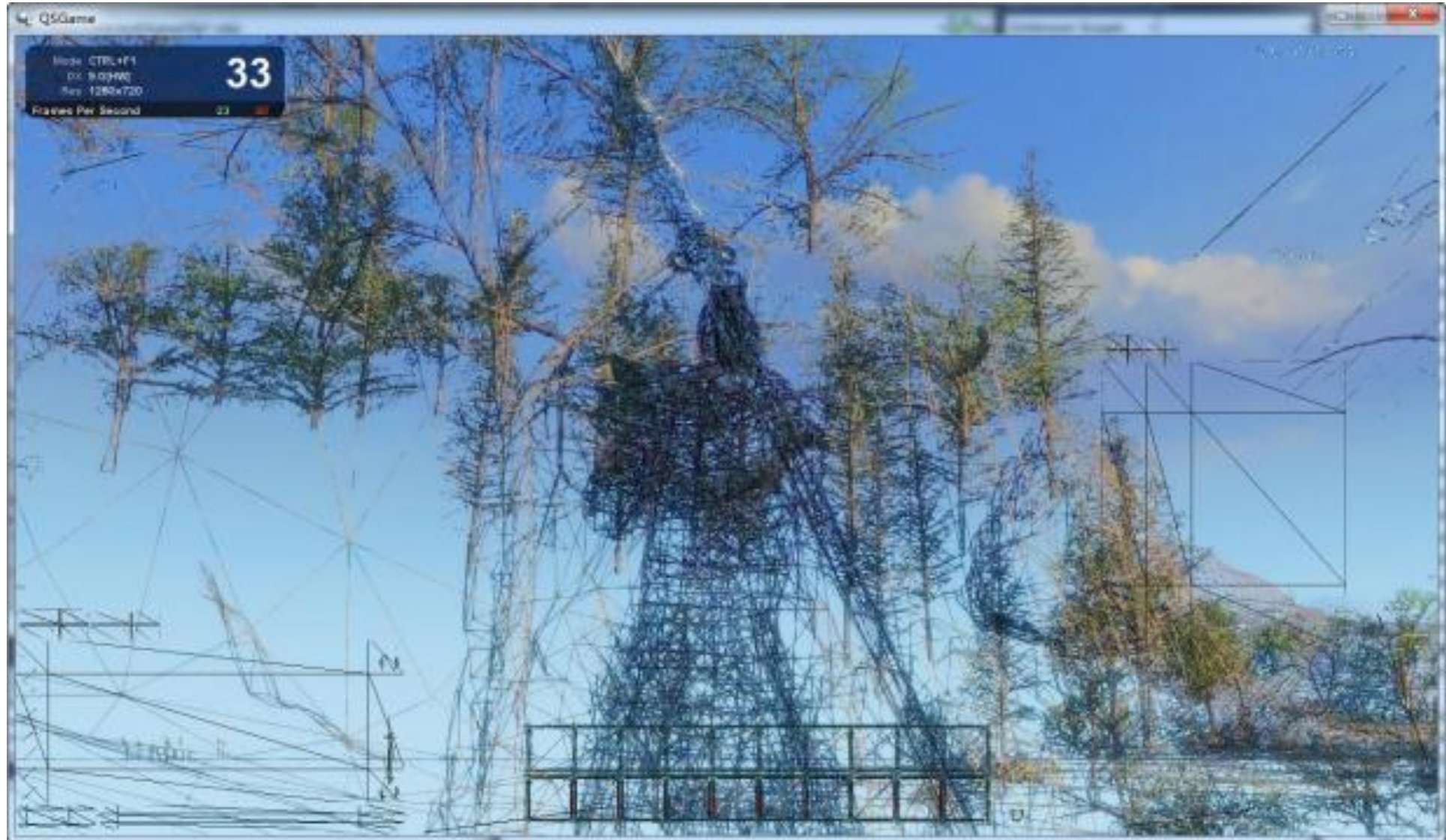


Data Optimization

- DumpTree
- TreeCulling
- Mipmapping



Occlusion Culling



Memory Optimization

- Used DefaultPool to allocate mapping and reduce memory usage
- Too much memory used a lot of memory

Stat	MemUsedAvg	MemUsedMax	% of Total
Memory Texture	38.17 MB	38.17 MB	0.00% [0 Bytes]
Memory Allocator	30.88 MB	30.88 MB	0.00% [0 Bytes]
Memory Vertex	104.12 MB	104.12 MB	0.00% [0 Bytes]
Memory Index	1.52 MB	1.52 MB	0.00% [0 Bytes]

Stat	MemUsedAvg	MemUsedMax	% of Total
Memory Texture	37.82 MB	37.82 MB	0.00% [0 Bytes]
Memory Allocator	30.09 MB	30.09 MB	0.00% [0 Bytes]
Memory Vertex	11.45 MB	11.45 MB	0.00% [0 Bytes]
Memory Index	1.76 MB	1.76 MB	0.00% [0 Bytes]

FarTree Performance

GPU performance without FarTree



GBufferConstruct	10.37 ms
GBufferHair	0.01 ms
GBufferOpaque	4.17 ms
GBufferSpeedTree	1.44 ms
GBufferTerrain	4.65 ms
GBufferRoad	0.01 ms
RenderDecal	0.01 ms
RenderShadowDecal	0.00 ms

GPU performance with FarTree

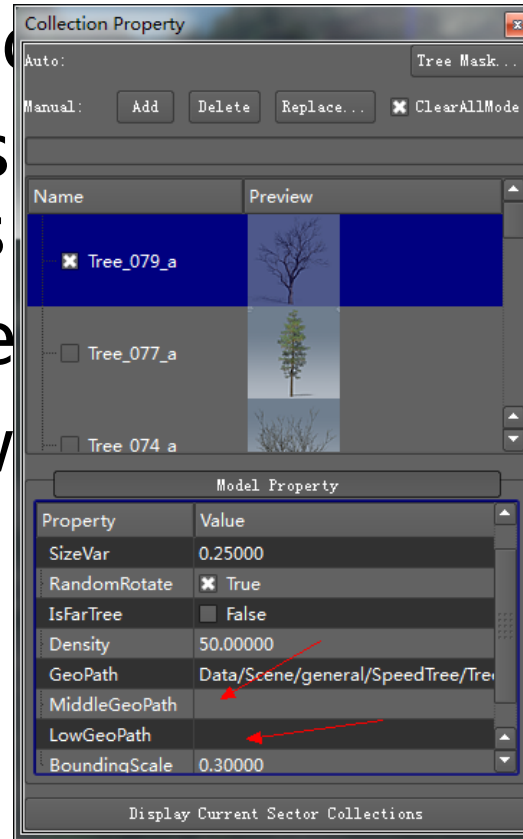


OverHeadDepthMask	0.00 ms
GBufferConstruct	10.82 ms
GBufferHair	0.01 ms
GBufferOpaque	4.08 ms
GBufferSpeedTree	3.05 ms
GBufferTerrain	3.58 ms
GBufferRoad	0.01 ms
RenderDecal	0.01 ms
RenderShadowDecal	0.00 ms
ScreenSpaceShadowMap	2.15 ms
LocalLightShadow	0.00 ms

- GPU overhead increased 0.5ms
- CPU overhead increased 0.5-1ms
- The number of trees increased from 2-3000 to 50-90k, significantly increasing the scene content

Low and medium configuration optimization

- Tree replacement reduced head
- Halved the texture sampling by 4 times reduced memory for
- Reduced the number of trees
- Decreased the show



Final results of far vegetation

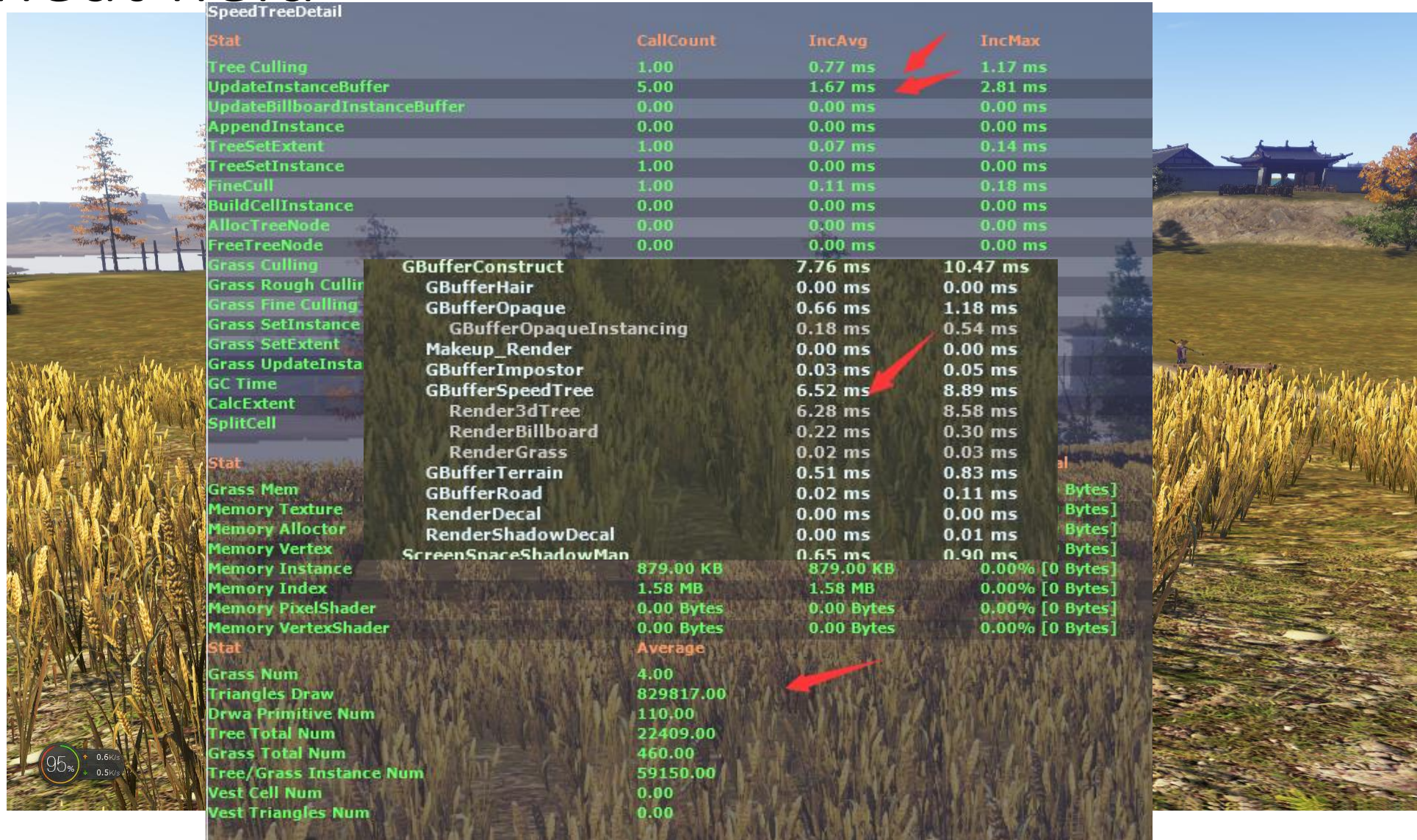


Flowers

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Wheat field



SpeedTreeDetail

Stat	CallCount	IncAvg	IncMax
Tree Culling	1.00	0.77 ms	1.17 ms
UpdateInstanceBuffer	5.00	1.67 ms	2.81 ms
UpdateBillboardInstanceBuffer	0.00	0.00 ms	0.00 ms
AppendInstance	0.00	0.00 ms	0.00 ms
TreeSetExtent	1.00	0.07 ms	0.14 ms
TreeSetInstance	1.00	0.00 ms	0.00 ms
FineCull	1.00	0.11 ms	0.18 ms
BuildCellInstance	0.00	0.00 ms	0.00 ms
AllocTreeNode	0.00	0.00 ms	0.00 ms
FreeTreeNode	0.00	0.00 ms	0.00 ms
Grass Culling	GBufferConstruct	7.76 ms	10.47 ms
Grass Rough Culling	GBufferHair	0.00 ms	0.00 ms
Grass Fine Culling	GBufferOpaque	0.66 ms	1.18 ms
Grass SetInstance	GBufferOpaqueInstancing	0.18 ms	0.54 ms
Grass SetExtent	Makeup_Render	0.00 ms	0.00 ms
Grass UpdateInsta	GBufferImpostor	0.03 ms	0.05 ms
GC Time	GBufferSpeedTree	6.52 ms	8.89 ms
CalcExtent	Render3dTree	6.28 ms	8.58 ms
SplitCell	RenderBillboard	0.22 ms	0.30 ms
	RenderGrass	0.02 ms	0.03 ms
Stat	GBufferTerrain	0.51 ms	0.83 ms
Grass Mem	GBufferRoad	0.02 ms	0.11 ms
Memory Texture	RenderDecal	0.00 ms	0.00 ms
Memory Allocator	RenderShadowDecal	0.00 ms	0.01 ms
Memory Vertex	ScreenSpaceShadowMan	0.65 ms	0.90 ms
Memory Instance		879.00 KB	879.00 KB
Memory Index		1.58 MB	1.58 MB
Memory PixelShader		0.00 Bytes	0.00 Bytes
Memory VertexShader		0.00 Bytes	0.00 Bytes
Stat	Average		
Grass Num	4.00		
Triangles Draw	829817.00		
Draw Primitive Num	110.00		
Tree Total Num	22409.00		
Grass Total Num	460.00		
Tree/Grass Instance Num	59150.00		
Vest Cell Num	0.00		
Vest Triangles Num	0.00		

95% 0.61/s 0.51/s

Impostor Rendering

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Basic ideas

- Offline Texture Generate
- Same objects share the same texture
- Instance finished at one time, and every object is a patch

Moonlight Blade requirements

- Not need to load the entity of small objects
- Fully automatic Cook Impostor Texture
- Offline Impostor taking over the rendering of all small objects
- Use one DP to draw all small objects

Impostor Practice

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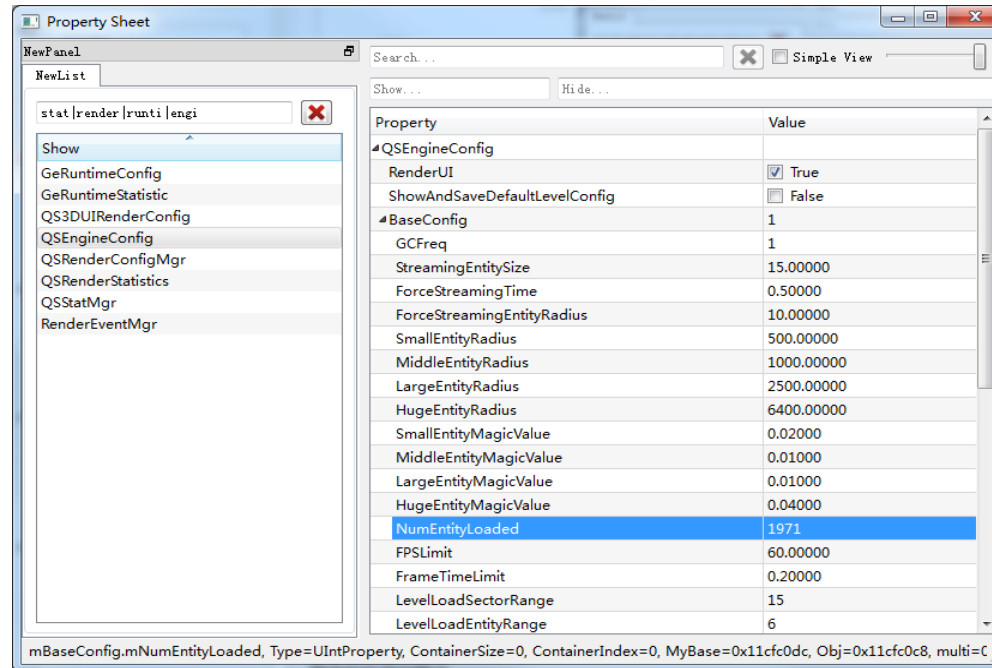


Home city performance test

- Entity number
- Memory
- CPU time
- GPU time
- Graphics card load
- Culling
- Reflection

Entity number

- Decreased from 2206 to 1971



CPU time

- MeshListParse saved 0.36ms
- Gbuffer saved 0.65ms

Mesh List Parse Time	1.00	1.04 ms	1.56 ms
GBuffer Opaque	1.00	1.63 ms	2.70 ms
GBuffer Terrain	1.00	0.53 ms	0.88 ms
GBuffer SpeedTree	1.00	0.40 ms	0.59 ms

Mesh List Parse Time	1.00	1.40 ms	1.92 ms
GBuffer Opaque	1.00	2.28 ms	3.02 ms
GBuffer Terrain	1.00	0.51 ms	0.69 ms
GBuffer SpeedTree	1.00	0.38 ms	0.46 ms

GPU time

- GBufferOpaque 1 4

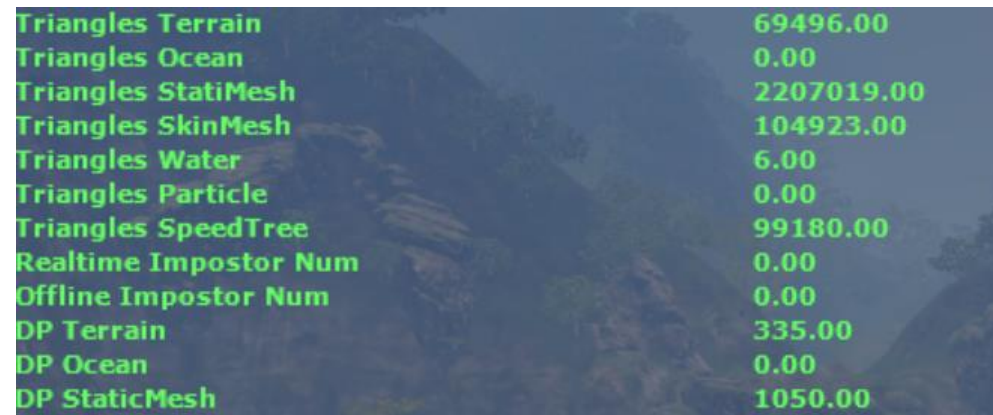
GBufferConstruct	6.30 ms	9.01 ms
GBufferHair	0.00 ms	0.00 ms
GBufferOpaque	5.22 ms	7.57 ms
GBufferOpaqueInstancing	0.40 ms	0.54 ms
Makeup_Render	0.01 ms	0.01 ms
GBufferImpostor	0.00 ms	0.00 ms
GBufferSpeedTree	0.82 ms	1.10 ms
GBufferTerrain	0.25 ms	0.33 ms
GBufferRoad	0.00 ms	0.00 ms
RenderDecal	0.00 ms	0.00 ms
RenderShadowDecal	0.00 ms	0.00 ms

GBufferConstruct	4.96 ms	7.22 ms
GBufferHair	0.00 ms	0.00 ms
GBufferOpaque	3.77 ms	5.63 ms
GBufferOpaqueInstancing	0.41 ms	1.07 ms
Makeup_Render	0.01 ms	0.01 ms
GBufferImpostor	0.15 ms	0.22 ms
GBufferSpeedTree	0.81 ms	1.46 ms
GBufferTerrain	0.21 ms	0.29 ms
GBufferRoad	0.00 ms	0.00 ms
RenderDecal	0.00 ms	0.00 ms
RenderShadowDecal	0.00 ms	0.02 ms

Graphics card load



Triangles Terrain	76080.00
Triangles Ocean	0.00
Triangles StatiMesh	1723201.00
Triangles SkinMesh	112347.00
Triangles Water	6.00
Triangles Particle	0.00
Triangles SpeedTree	97660.00
Realtime Impostor Num	0.00
Offline Impostor Num	4180.00
DP Terrain	351.00
DP Ocean	0.00
DP StaticMesh	791.00



Triangles Terrain	69496.00
Triangles Ocean	0.00
Triangles StatiMesh	2207019.00
Triangles SkinMesh	104923.00
Triangles Water	6.00
Triangles Particle	0.00
Triangles SpeedTree	99180.00
Realtime Impostor Num	0.00
Offline Impostor Num	0.00
DP Terrain	335.00
DP Ocean	0.00
DP StaticMesh	1050.00

Culling

- Impostor adding additional visibility needs 1ms
- Not Load far entity
- Raster Obb time reduced from 2ms to 0.5ms!!!
- Basically the same

Reflection

- CPU time saved 0.35ms
- GPU time saved 0.4ms

TranslucencyRender	2.98 ms	4.74 ms	
ResidueEffect	0.00 ms	0.00 ms	
RenderWaterAndTranslucency	2.98 ms	4.74 ms	
UpdateWave	0.00 ms	0.01 ms	4.25 ms
InvFFT	0.07 ms	0.09 ms	2.63 ms
RestoreRefraction	0.38 ms	0.51 ms	0.78 ms
RenderWaterSelf	0.00 ms	0.00 ms	0.32 ms
RenderWaterSelf	0.00 ms	0.00 ms	1.49 ms
WaterRenderRef	2.48 ms	4.07 ms	0.26 ms
RenderWaterSelf	0.02 ms	0.03 ms	0.00 ms
SourceCurrentDraw Impostor Refelect	1.00	0.00 ms	0.00 ms

Water Refelect		1.00	3.04 ms	4.41 ms
WaterRef Lis	TranslucencyRender	2.55 ms	3.90 ms	2.77 ms
WaterRef Op	ResidueEffect	0.00 ms	0.00 ms	0.64 ms
WaterRef Te	RenderWaterAndTranslucency	2.55 ms	3.90 ms	0.64 ms
Draw Opaqu	UpdateWave	0.00 ms	0.00 ms	1.36 ms
Draw Terrain	InvFFT	0.06 ms	0.08 ms	0.29 ms
SourceCurre	RestoreRefraction	0.34 ms	0.48 ms	0.04 ms
	RenderWaterSelf	0.00 ms	0.00 ms	
	RenderWaterSelf	0.00 ms	0.00 ms	
	WaterRenderRef	2.10 ms	3.26 ms	
	RenderWaterSelf	0.02 ms	0.03 ms	

Hidden Buff of Reflection

- Thinking out of the box
 - Reflection and main Camera clipping together
- Results
 - Reflection and main Camera shared the results of Culling
 - Reflection and main Camera shared Instance Buffer filling
 - Reflection and main Camera became two unions, the performance will double when using head-up camera😊
 - Whole scene reflected Impostor
- Philosophy behind
 - Seek common ground

Offline Impostor summary

- Increased the content of far scenes
- Drew more graphics, but brought better performance
- Graphic quality slightly degraded, but is still acceptable at a far distance coupled with fog
- Has passed the third test

Data Optimization

- Product-oriented
- Definition of appropriate resources
- In-depth analysis of gameplay concentrated areas
- Very good output

Data Optimization

- Rocks with mixing textures
- Model LOD
- Internal bounding box
- Vegetation data optimization

Rocks with mixing textures

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Rock Optimization	Number of triangles	GPU time	FPS
Before	220w	13ms	22
After	63w	5.1ms	32

Model Optimization

- LOD
 - Most models have lod, because the feature of lod/pop switching is not enabled
 - Dongyue case was quite a shock, so we decided to enable lod
 - Successfully resolved the problem of lod switching (screen door)
- The hair occupied too much two-sided triangles
 - Simplified, and enforced CW at a far distance
- Two-sided texture
 - Only a small part of model require two-sided texture
- AlphaTest
 - Only a small part of model require alphatest to split the models

Internal bounding box

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Vegetation data optimization

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Results of data optimization

- First solved
- Brought con
- Shared the s
teams

地图名	坐标	优化前 FPS	优化后 FPS	
巴蜀	巴蜀：洞悉林 1283,902	28	33	
杭州	杭州：钱塘门 2084,1325	57	59	
	杭州：杭州城 2162,1185	36	41	
	杭州：杭州城 2011,923	46	52	
	杭州：杭州城 2012,1259	28	35	
	杭州：红衣林 1801,2773	34	38	
开封	开封：开封 1997,1041	35	36	
	开封：皇城 2357,1173	33	39	
	开封：尧山 1515,849	22	36	
	开封：飞霞渡 1126,1250	28	36	天下镖
	开封：尧山 1292,1001	27	34	天下镖
	开封：西水关 1595,1258	34	44	
	云贵：桐梓湖 1473,2502	25	30	
徐海	徐海：平阳驿站 1460,2121	27	30	
	徐海：平阳驿站 1176,1839	30	33	
荆湖	荆湖：聚贤团 1420,1114	32	34	
	荆湖：聚贤团 993,1018	35	36	

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