

# Compute Shader

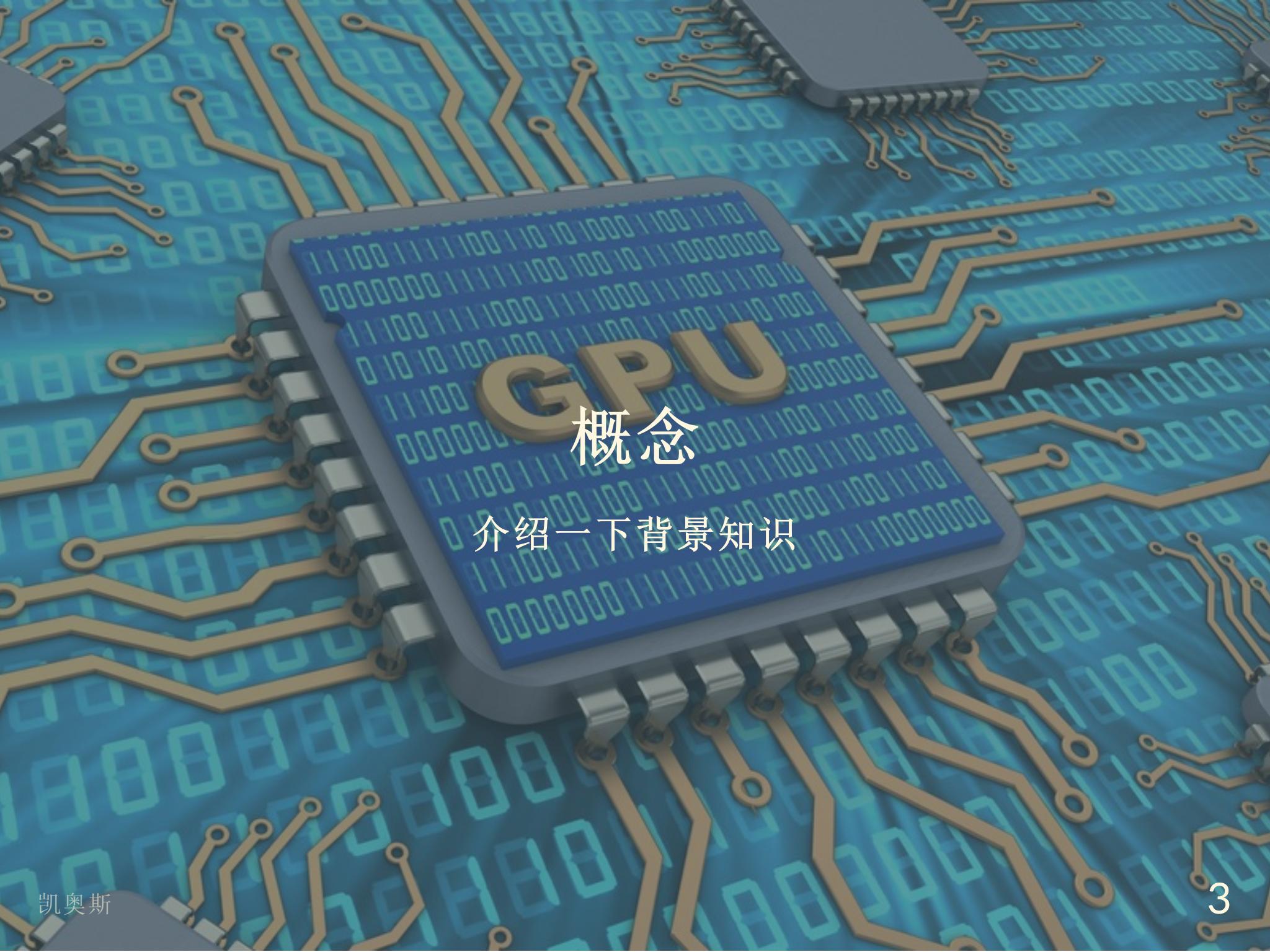


**Optimize your game using compute**

凯奥斯

# Compute Shader

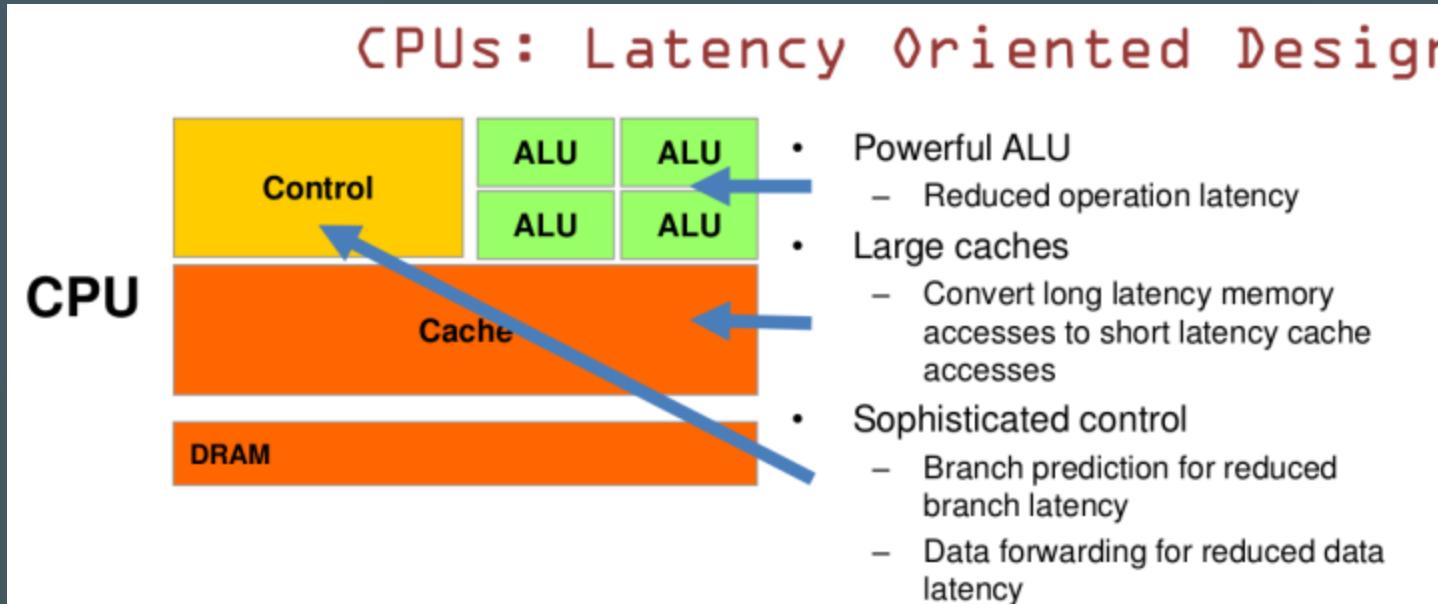
- 概念
- 语法
- 用途



# GPU 概念

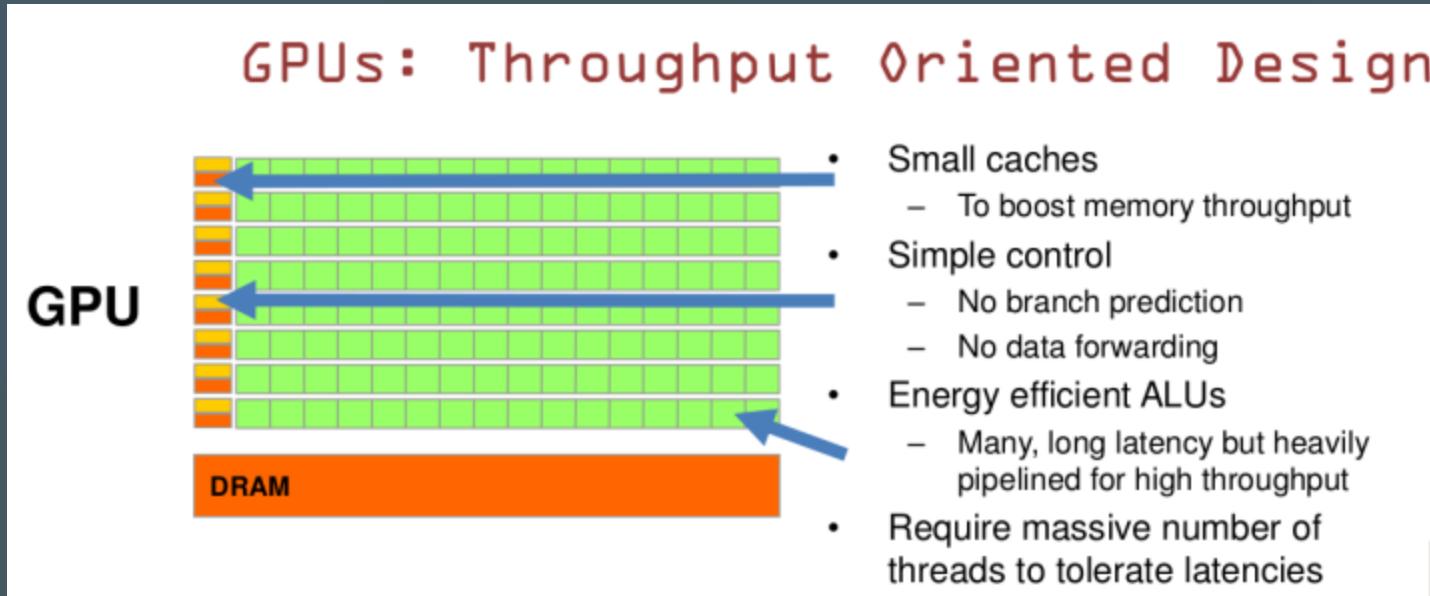
介绍一下背景知识

# CPU是基于低延迟的设计



CPU擅长逻辑控制和串行的运算。

# GPU是基于大吞吐量的设计



GPU适用于计算密集型和易于并发的程序。

# GPGPU

Plain Old  
CPU Processing

GPGPU  
Processing



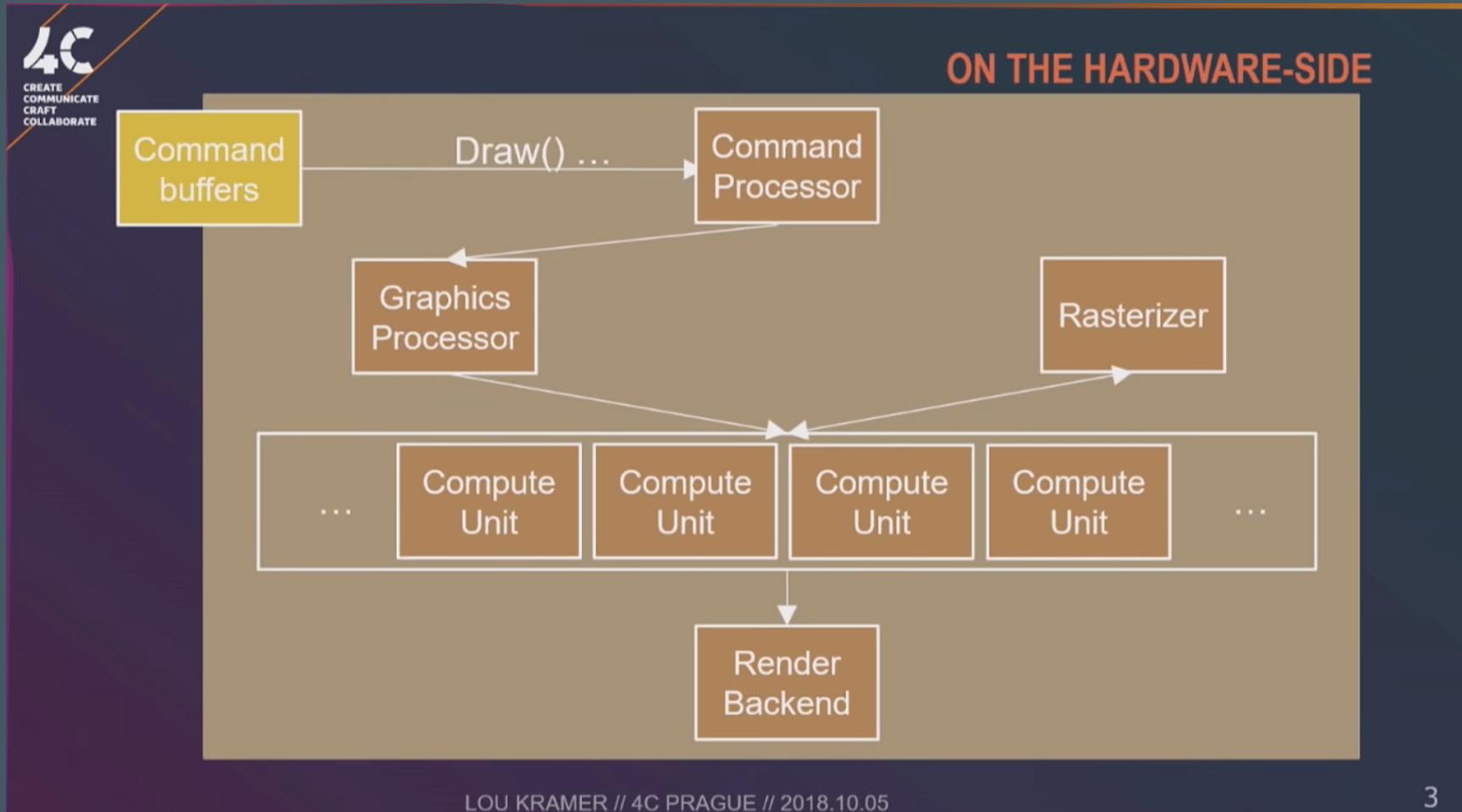
# 支持Compute Shader的图形API



# Compute管线与图形管线的对比

Graphics pipeline	Compute pipeline
One to several shader stages (VS, HS, DS, GS, PS) Input assembler Tessellation Rasterizer ...	CS shader stage

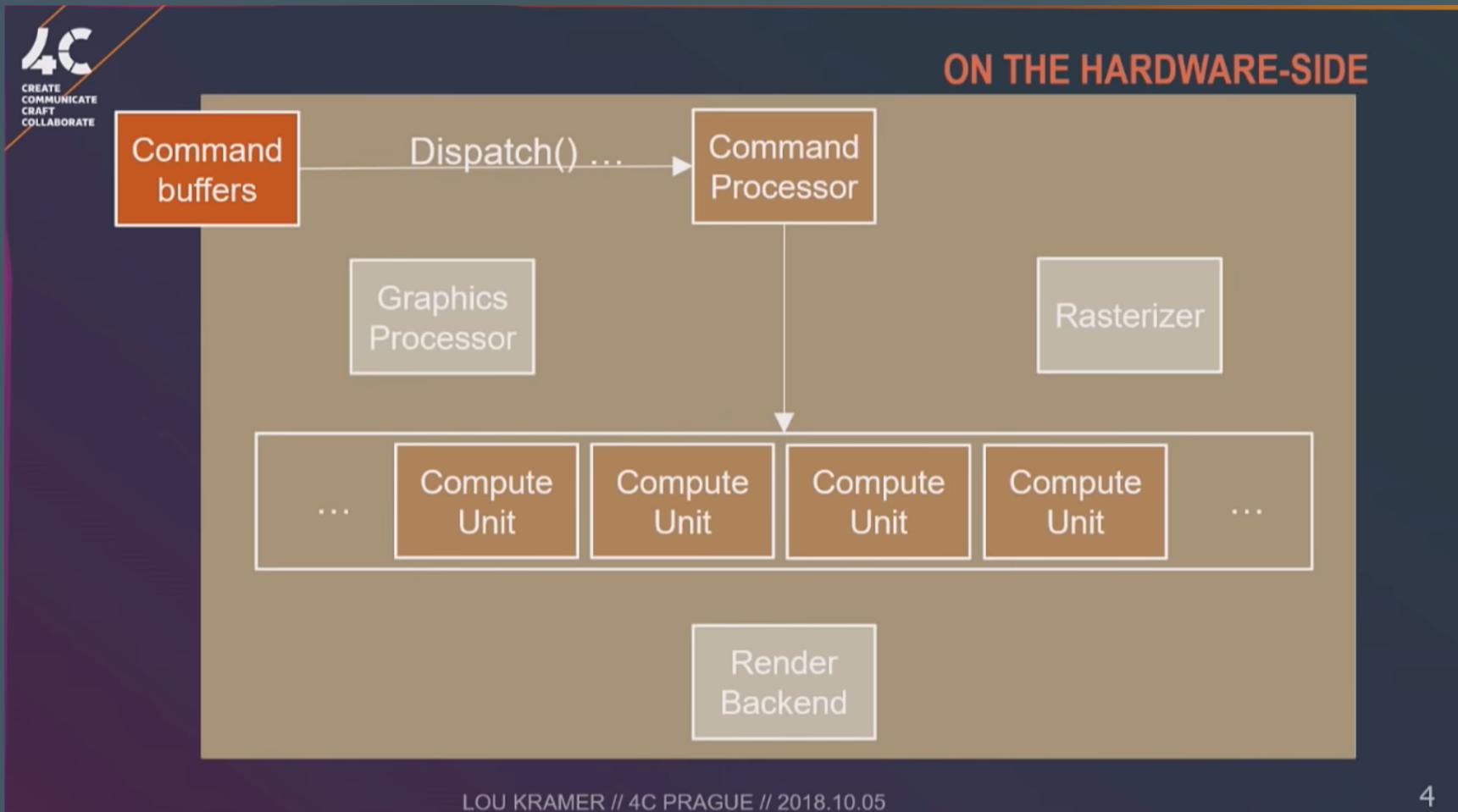
# 图形管线（硬件端）



LOU KRAMER // 4C PRAGUE // 2018.10.05

3

# 计算管线（硬件端）



LOU KRAMER // 4C PRAGUE // 2018.10.05

4



# 语法

## 如何在**Unity**里使用**Compute Shader**

# kernel

```
// test.compute
#pragma kernel FillWithRed

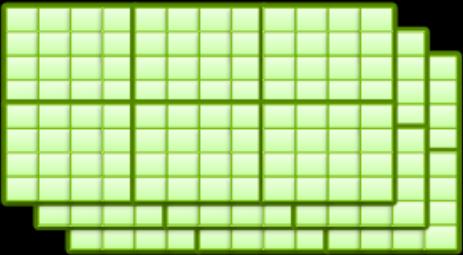
RWTexture2D<float4> res;

[numthreads(8,8,1)]
void FillWithRed (uint3 dtid : SV_DispatchThreadID)
{
    res[dtid.xy] = float4(1,0,0,1);
}
```

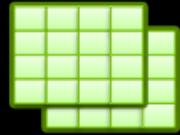
# Dispatch

```
public void Dispatch(int kernelIndex,  
                     int threadGroupsX,  
                     int threadGroupsY,  
                     int threadGroupsZ);
```

# numthreads



**Dispatch:** 3D grid of thread groups. Hundreds of thousands of threads.



**Thread Group:** 3D grid of threads. Tens or hundreds of threads.

**numThreads** nX, nY, nZ

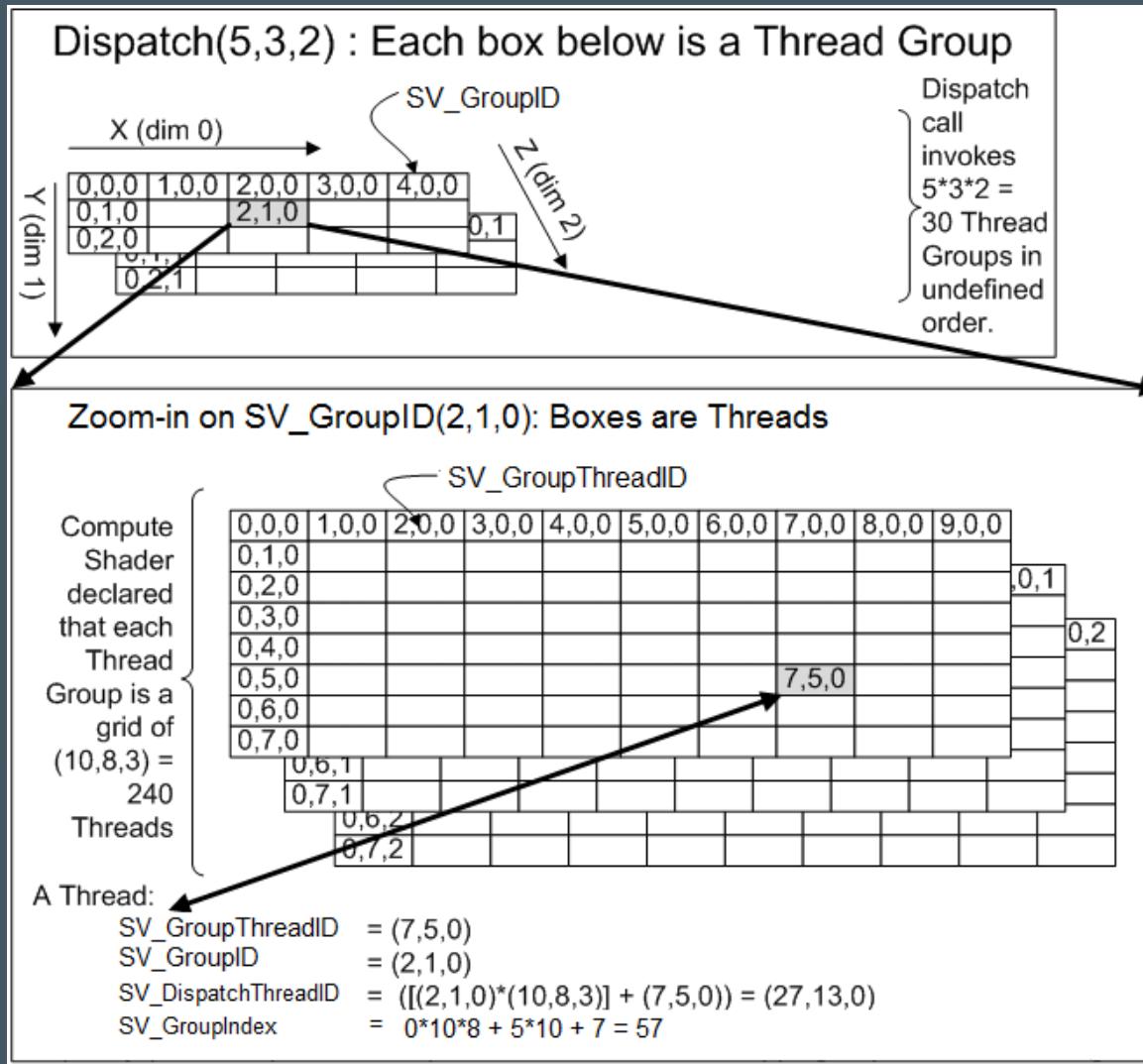


**Thread:** One invocation of a shader.

`SV_DispatchThreadID,`  
`SV_GroupThreadID,`  
`SV_GroupID`

PRESENTED BY  NVIDIA.

# thread groups



# Buffer & Texture

GPU Side	CPU Side
*StructuredBuffer	ComputeBuffer
RWTexture*D	RenderTexture

# groupshared

使用**groupshared**可以将一个变量标记为组内共享（又叫**TGSM**）。

使用这种变量，就可以在**thread group**内进行通讯。

# Barrier

当我们在不同线程访问同一个资源的时候，我们需要使用barrier来进行阻塞和同步。

GroupMemoryBarrier

DeviceMemoryBarrier

AllMemoryBarrier

DeviceMemoryBarrierWithGroupSync

GroupMemoryBarrierWithGroupSync

AllMemoryBarrierWithGroupSync

# Interlocked

原子操作， 不会被线程调度机制打断。

- InterlockedAdd
- InterlockedAnd
- InterlockedCompareExchange
- InterlockedCompareStore
- InterlockedExchange
- InterlockedMax
- InterlockedMin
- InterlockedOr
- InterlockedXor

但是只能用于*int/uint*

# 平台差异

1. 数组越界， DX上会返回0， 其它平台会出错。
2. 变量名与关键字/内置库函数重名， DX无影响， 其他平台会出错。
3. 如果SBuffer内结构的显存布局要与内存布局不一致， DX可能会转换， 其他平台会出错。
4. 未初始化的SBuffer或Texture，在某些平台上会全部是0， 但是另外一些可能是任意值， 甚至是NaN。
5. Metal不支持对纹理的原子操作， 不支持对SBuffer调用**GetDimensions**。
6. ES 3.1在一个CS里至少支持4个SBuffer（所以， 我们需要将相关联的数据定义为struct）。

# 性能

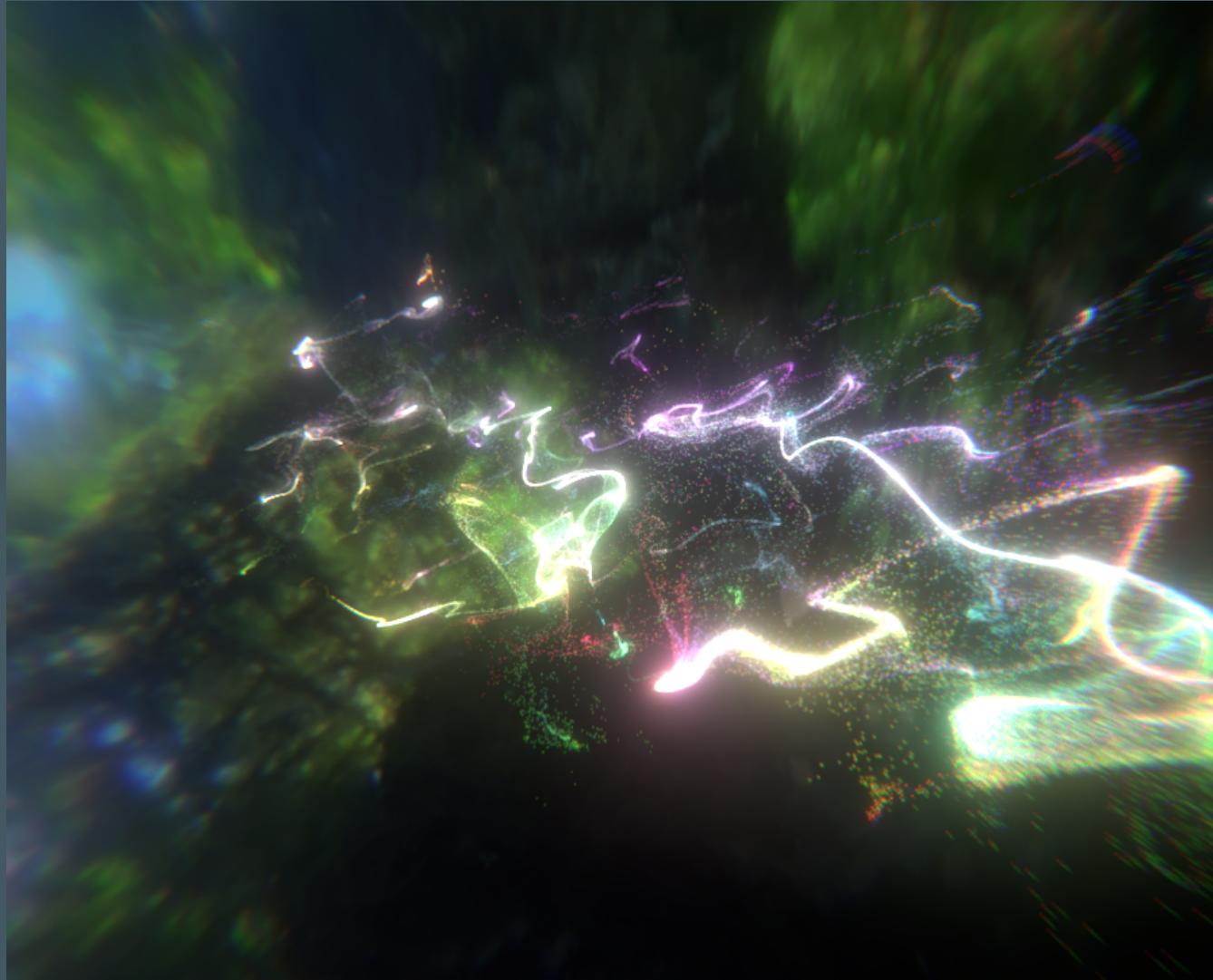
1. 尽量减少Group之间的交互
2. GPU一次Dispatch会调用64（AMD）或32（NVIDIA）个线程，所以，numthreads的乘积最好是这个值的整数倍。
3. 避免回读
4. 避免分支，重点避免在thread group中间的分支
5. 尽量保证内存连续性
6. 使用[unroll]来打开循环，有些时候需要手动unroll

The background of the slide is a dark, atmospheric landscape. In the upper right, a city is built on large, craggy rock formations. The city features various architectural styles with domes, towers, and arched windows. In the lower center, a small, isolated stone tower stands on a rocky outcrop. The sky is filled with heavy, dark clouds, with some lighter areas suggesting a setting or rising sun. The overall mood is mysterious and grand.

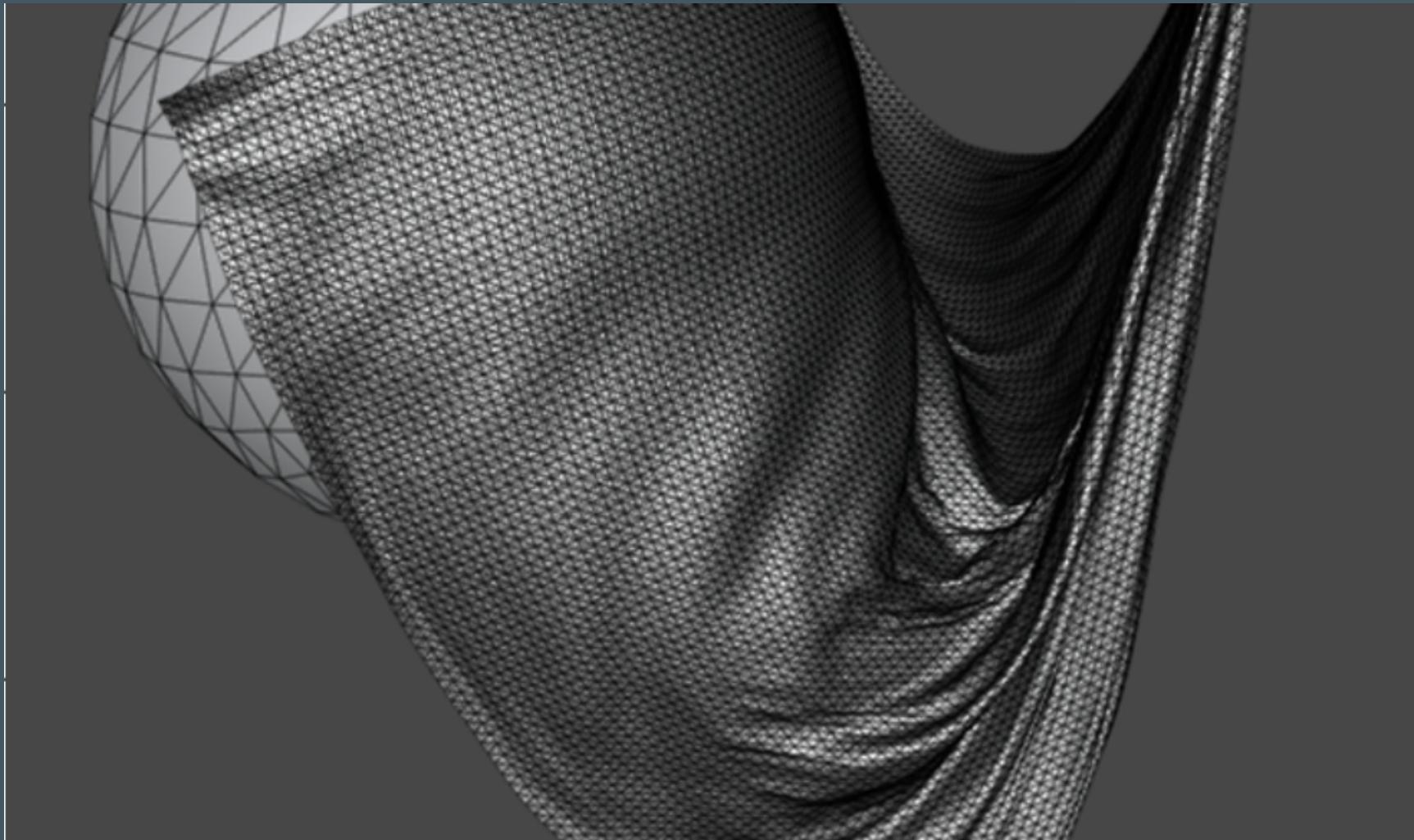
# 应用

目前有哪些应用

# GPU Particle System



# GPU Simulation



# Image Processing

F1 - Desaturate

F2 - Circles

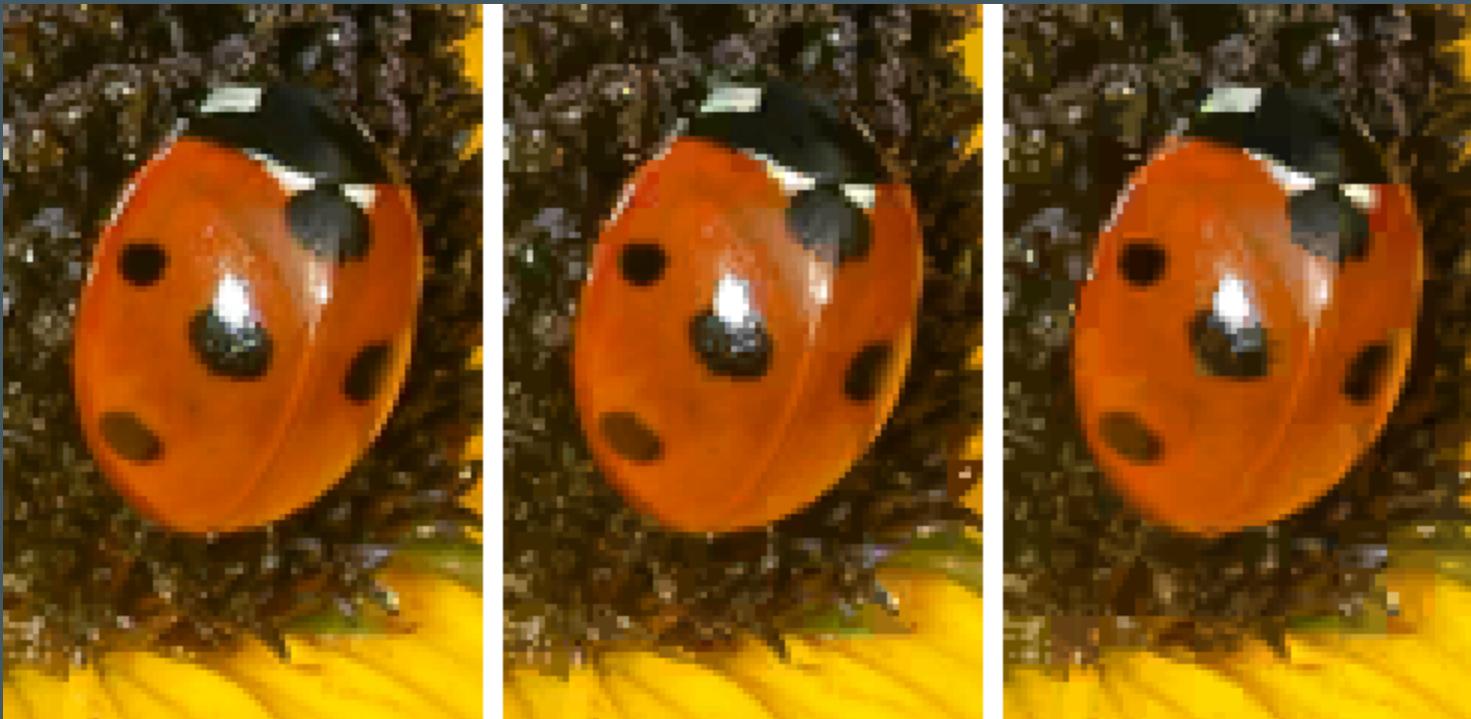


F1 - Desaturate

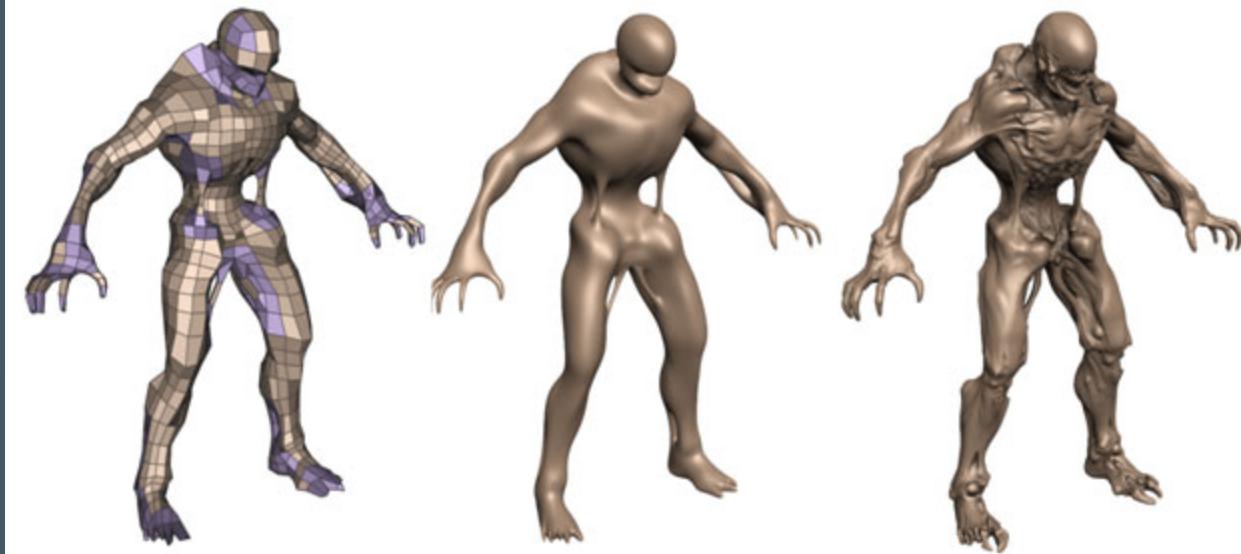
F2 - Circles



# Image Compression



# Tessellation



# Local lights culling



# Occlusion culling



# GPU Driven Rendering Pipeline



还有很多很多.....



# 引用

1. [Graphic Processing Processors \(GPUs\) Parallel Programming](#)
2. [DirectCompute Optimizations and Best Practices](#)
3. [Compute Shaders: Optimize your engine using compute / Lou Kramer, AMD \(video\)](#)
4. [Introduction to Compute Shaders in Vulkan](#)
5. [Compute Shader\(OpenGL\)](#)
6. [Compute Shader Overview\(Direct3D 11\)](#)

# 引用

7. [About Threads and Threadgroups\(Metal\)](#)
8. [ARM® Mali™ GPU OpenCL Developer Guide\(Version 3.2\)](#)
9. Real-Time Rendering 3rd Edition. Chapter 18
10. [GPU Particles \(Github\)](#)
11. [GPU Cloth Tool](#)
12. [Compute Shader Filters](#)
13. [Adaptive Scalable Texture Compression](#)

# 引用

14. Introduction to 3D Game Programming with DirectX 11
15. [DirectX 11 Tessellation \(NVIDIA\)](#)
16. [DirectX 11 Rendering in Battlefield 3](#)
17. [Hi-Z GPU Occlusion Culling](#)
18. [GPU-Driven Rendering Pipelines](#)
19. <https://docs.unity3d.com>
20. [Problems with ComputeBuffer Readback](#)
21. [Volume Tiled Forward Shading \(Github\)](#)

# 引用

22. Low-level Shader Optimization for Next-Gen and DX11 ([ppt](#)) ([video](#))
23. [Post-processing Stack v2 \(Github\)](#)
24. 数字图像处理（冈萨雷斯）
25. [General-purpose computing on graphics processing units \(Wikipedia\)](#)
26. 全局光照技术：从离线到实时渲染
27. [Mythbusters Demo GPU versus CPU \( NVIDIA \)](#)
28. [Glops](#)