GPU Computing Technology Overview

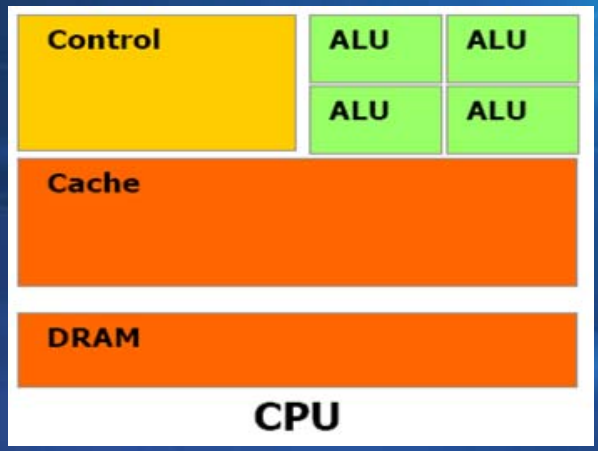
赵开勇
香港浸会大学/浪潮GPU高性能开发顾问
CUDA社区版主
http://blog.csdn.net/openhero

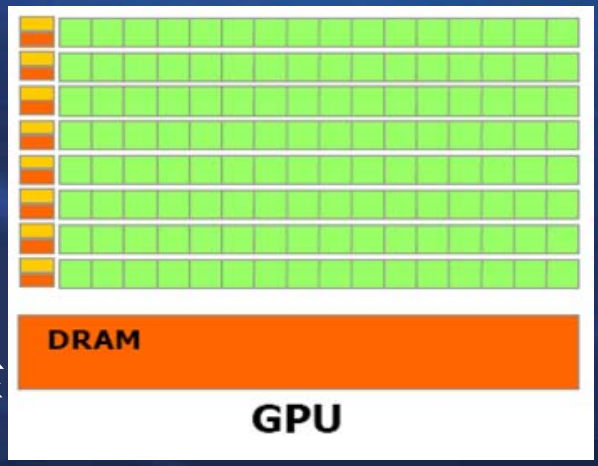
提纲

- 处理器核心技术趋势和现状
- 硬件架构简介
  - Nvidia: G80， GTX200
  - AMD(ATI) : R600， RV770
  - Intel(Larrabee)
- 软件编程模型简介
  - Nvidia: CUDA
  - AMD(ATI): Stream computing
  - Intel: Ct
- 应用与优化

处理器核心技术趋势和现状

- 处理器核心技术趋势
  - 高效的计算能力
    - 利用数据的并行性
  - 高效的数据带宽
    - 增加片内通信，减少片外通信
  - 降低指令级的控制复杂度
    - out-of-order vs in-order
  - 流水线式处理模式
    - 每一个环节只处理大量简单的工作
  - 低功耗





GPU技术的现状及优势

- 强大的并行处理能力 GPU接近
  - Single float: 1T
  - Double float: 100G~200G
- 高带宽
  - 141GB/s (GTX280),115 GB/s(RV770)
- 低成本
  - Gflop/$和Gflops/w高于CPU
- 扩展性
  - CPU的协处理器，现有的PCIE都可扩展

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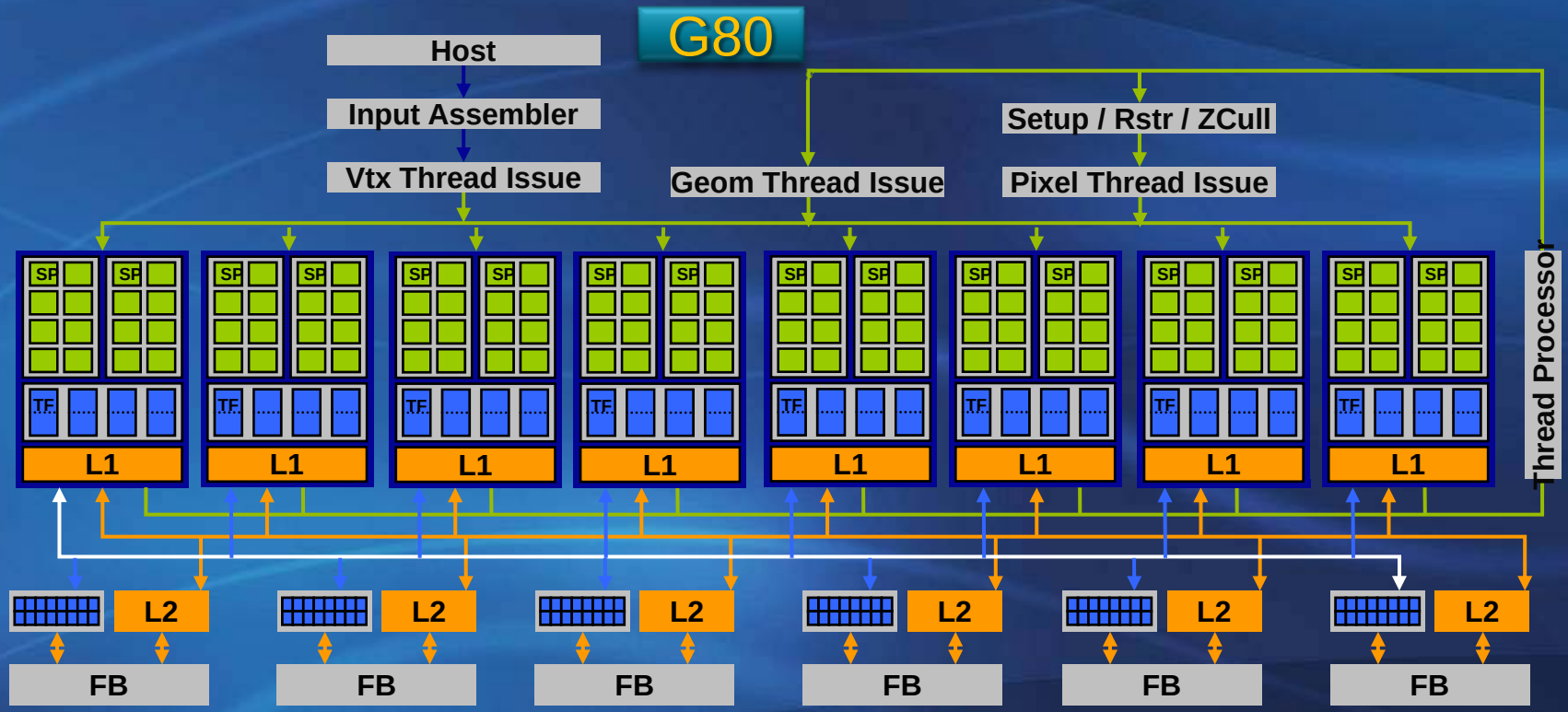
GPU技术路线的分析

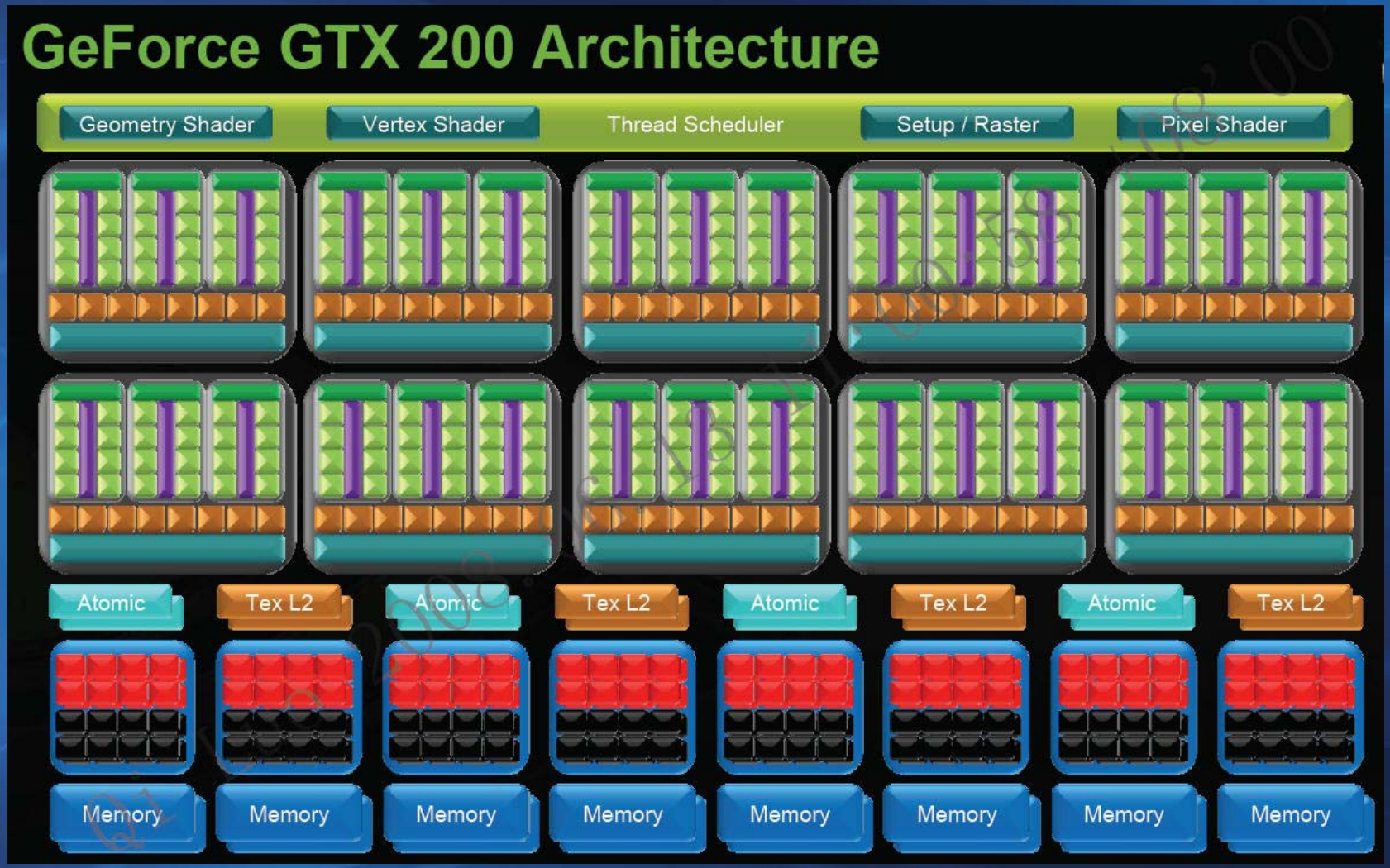
硬件：

硬件	Nvidia(GT200)	AMD(RV770)	Intel(Larrabee)
单个处理单元	8SP+2SFU+1DU	16x(4ALU+1SFU+1DU)	2 in-order core
总处理单元	240SP	160x5 = 800	32
线程	Thread:SP 1:1	Thread:ALU 1:5	Thread:core 4:2
时钟频率	1296MHz	750MHz	未知
DRAM	GDDR3	GDDR5	GDDR5
内存访问模式	Global+shared	Global+shared	Shared
内存位宽	512bit	512bit	1024-bit

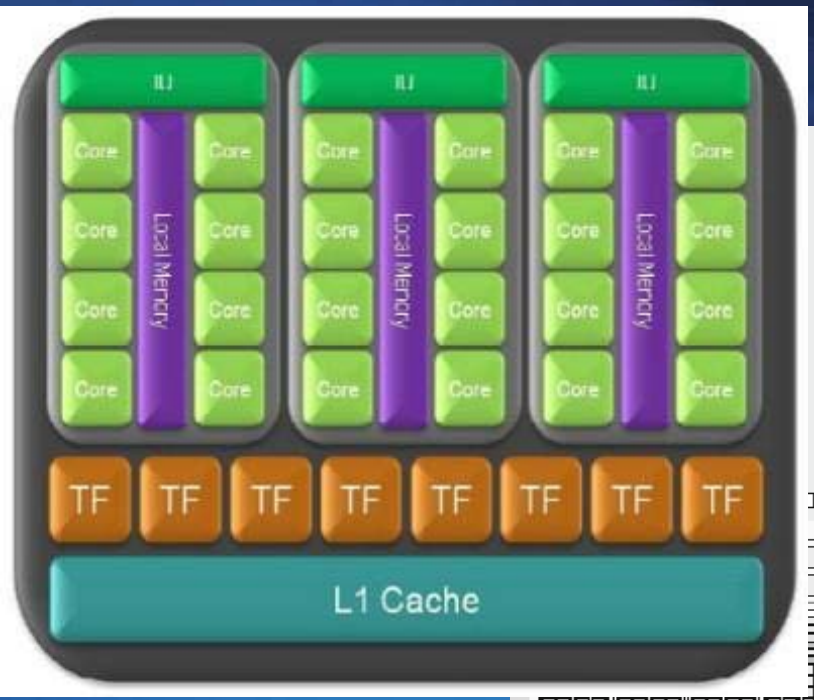
Nvidia G80、GTX200硬件架构

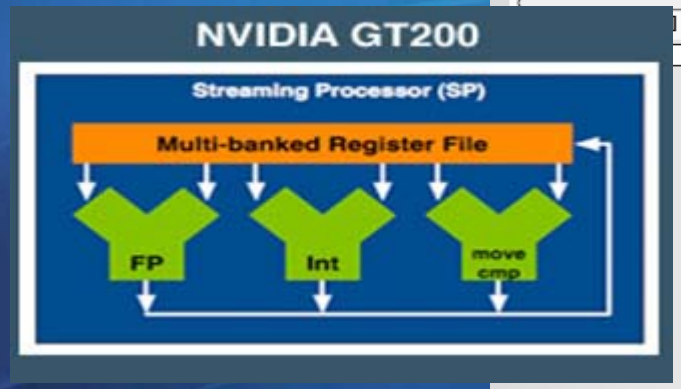


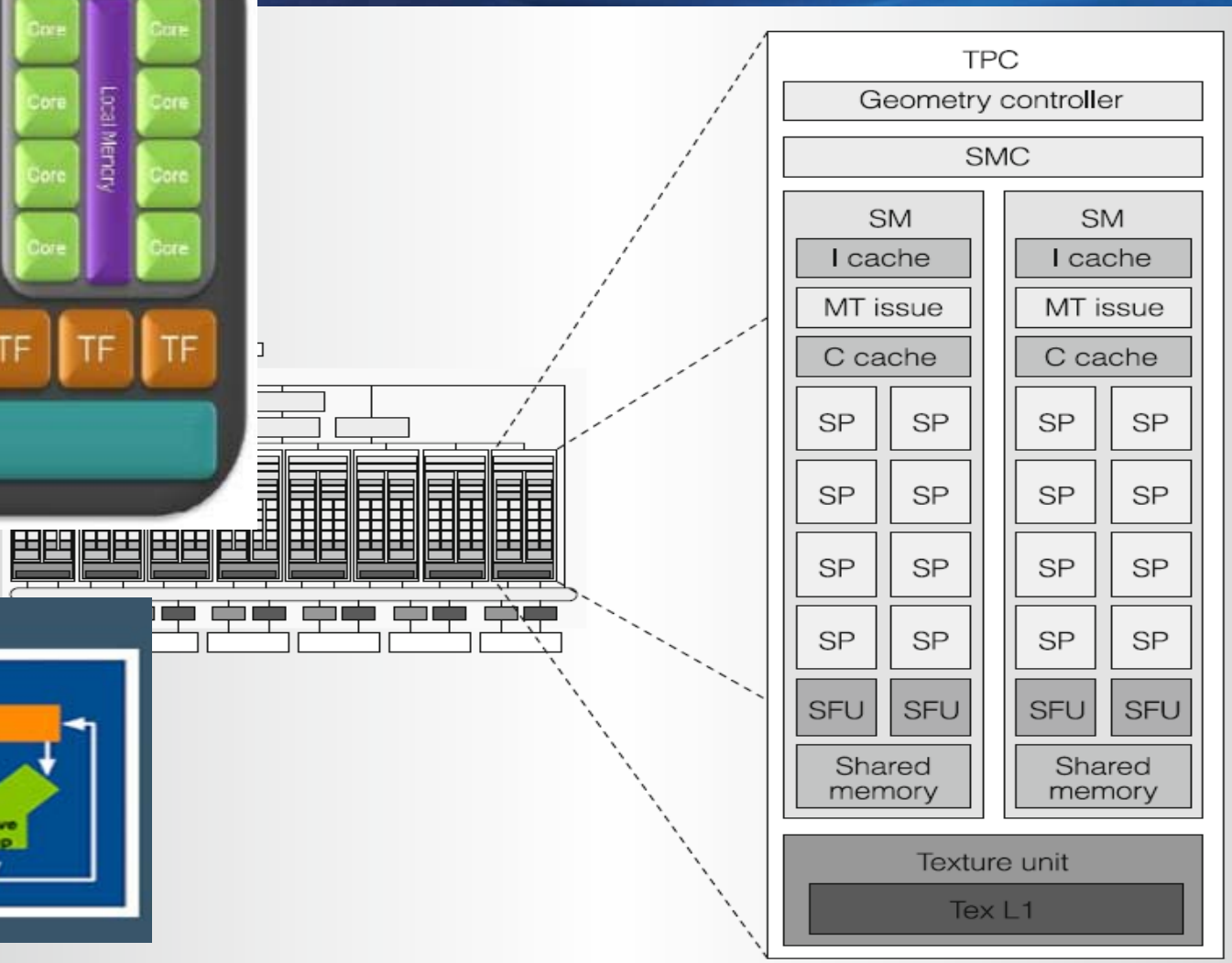
Nvidia G80、GTX200硬件架构



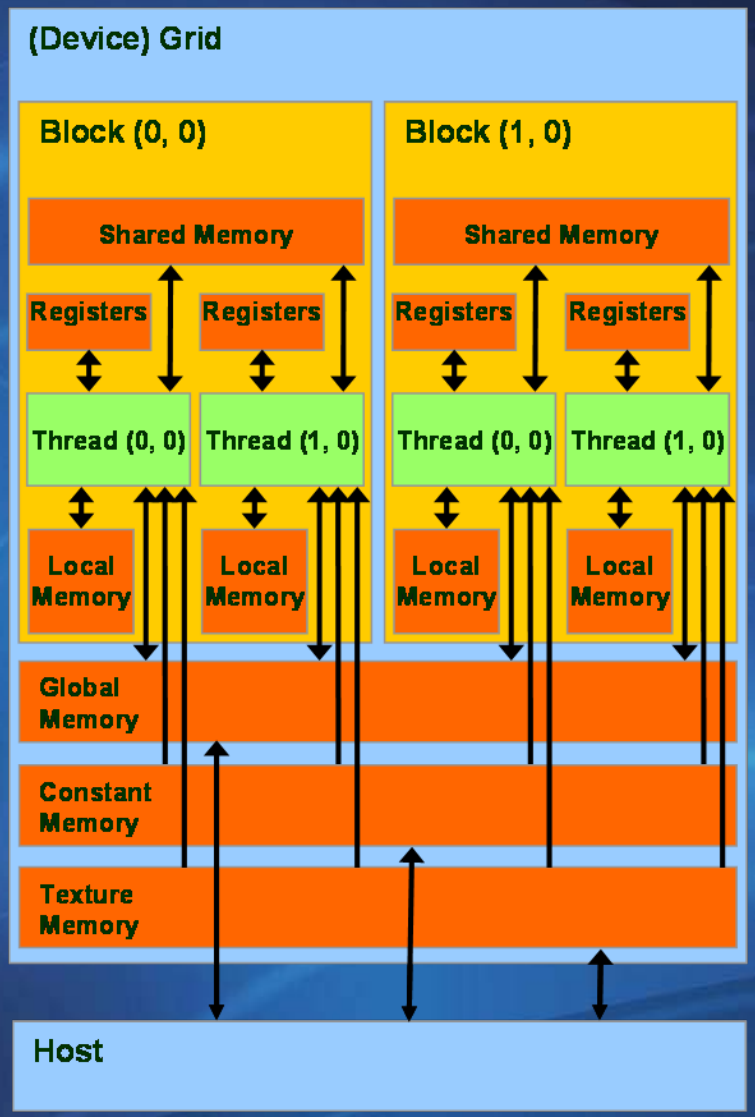
Nvidia 计算单元(TPC, SM, SP)

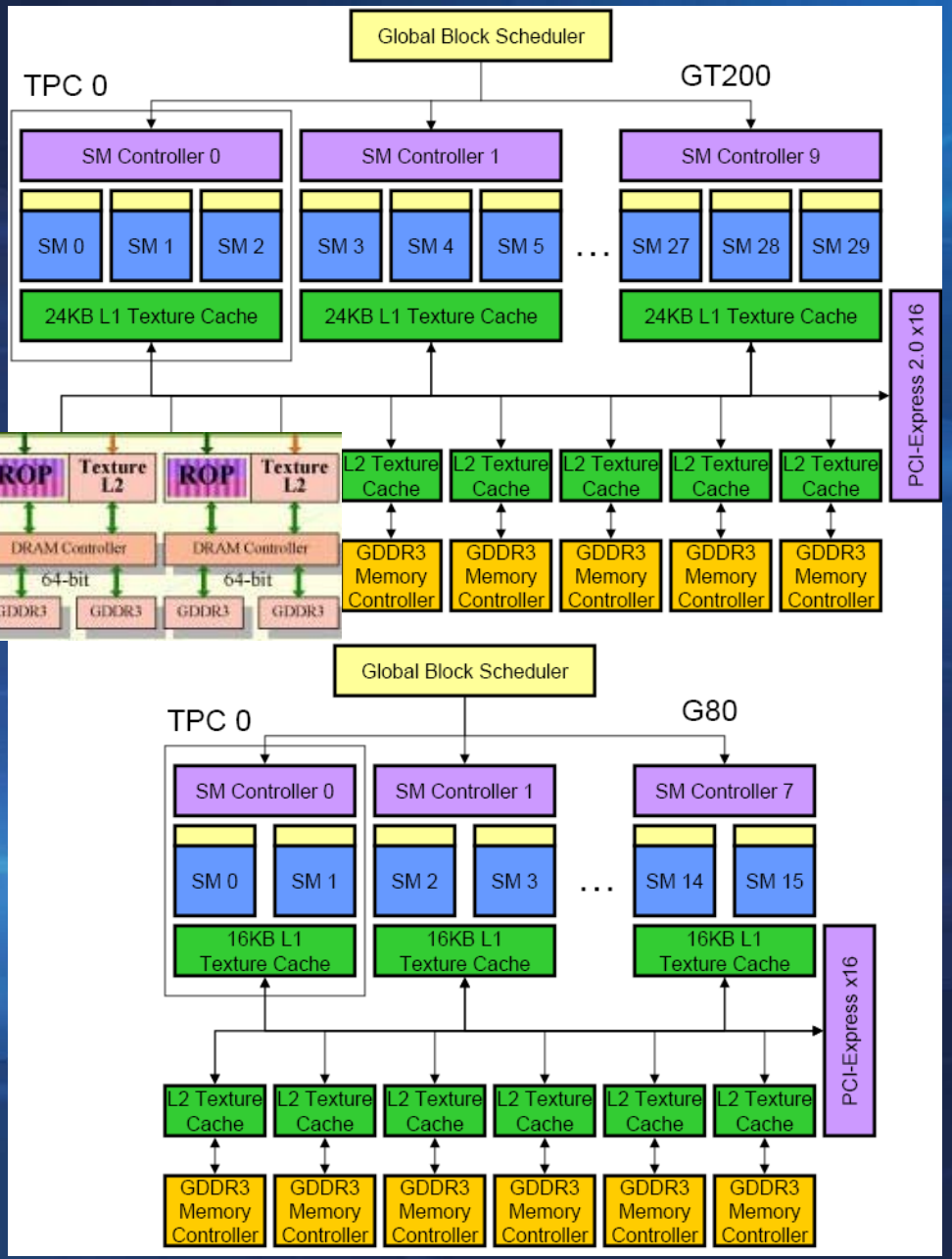




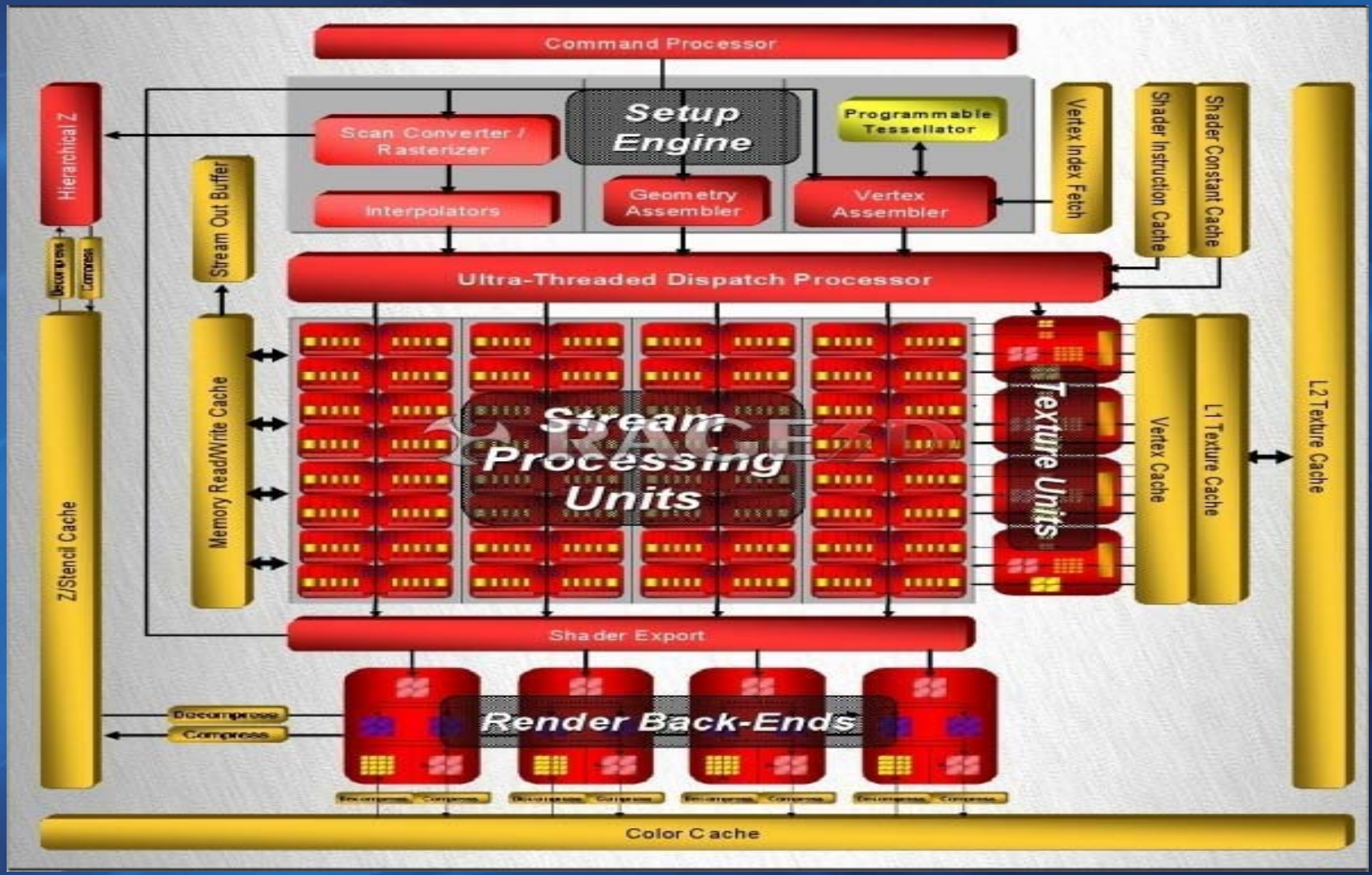


Nvidia 内存


(Device) Grid
Block (0, 0)
Block (1, 0)
Shared Memory
Registers
Thread (0, 0)
Thread (1, 0)
Local Memory
Global Memory
Constant Memory
Texture Memory
Host


Global Block Scheduler
TPC 0
GT200
SM Controller 0
SM Controller 1
SM Controller 9
SM 0
SM 1
SM 2
SM 3
SM 4
SM 5
SM 27
SM 28
SM 29
24KB L1 Texture Cache
ROP
Texture L2
DRAM Controller
64-bit
GDDR3
L2 Texture Cache
GDDR3 Memory Controller
PCI-Express 2.0 x16
Global Block Scheduler
TPC 0
G80
SM Controller 0
SM Controller 1
SM Controller 7
SM 0
SM 1
SM 2
SM 3
SM 14
SM 15
16KB L1 Texture Cache
L2 Texture Cache
GDDR3 Memory Controller
PCI-Express x16

AMD(ATI) R600, RV770硬件架构



R600

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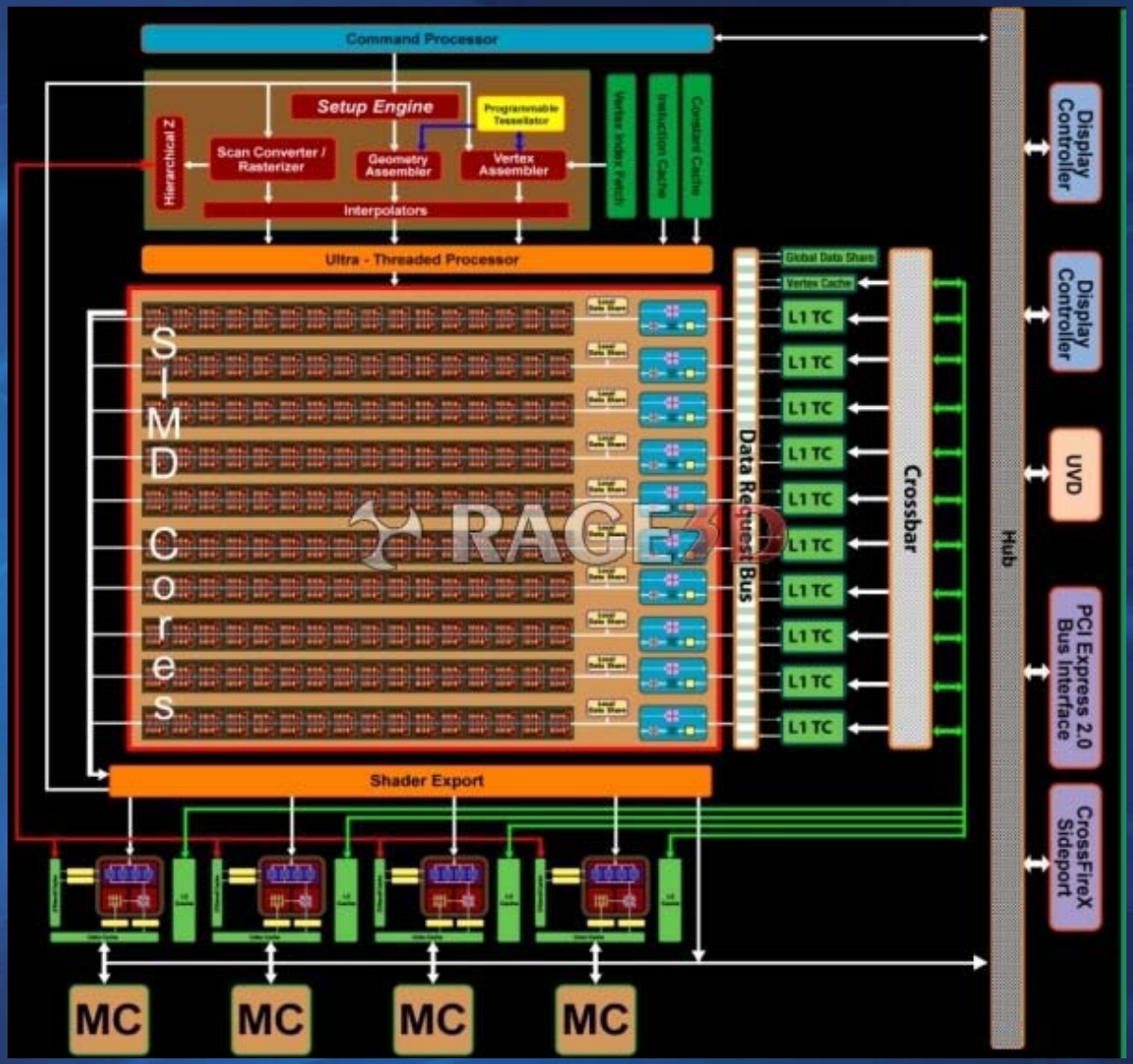
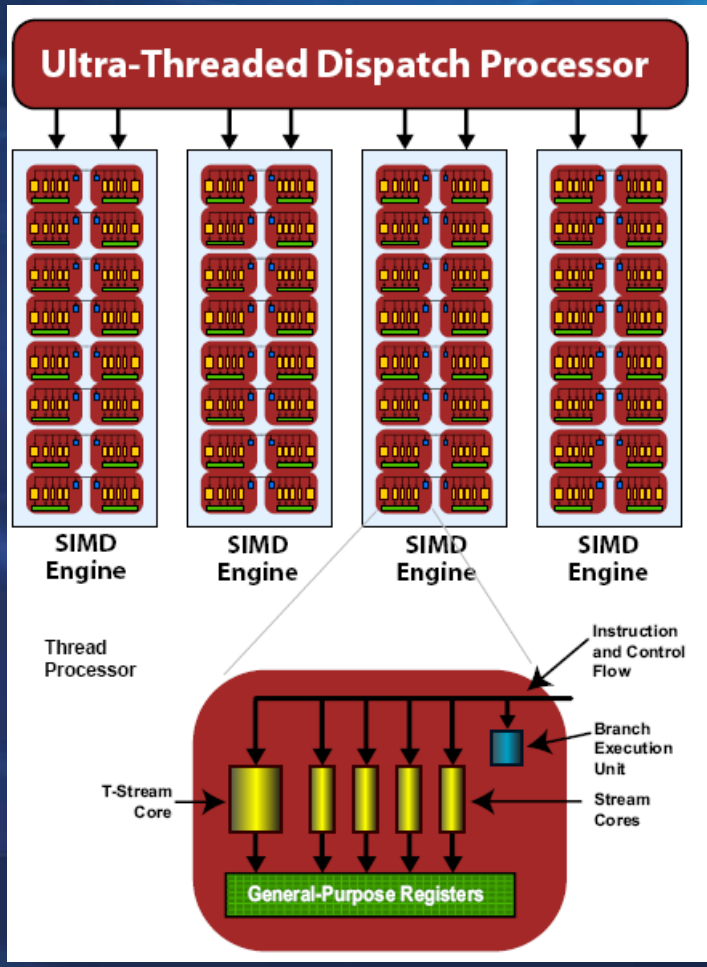
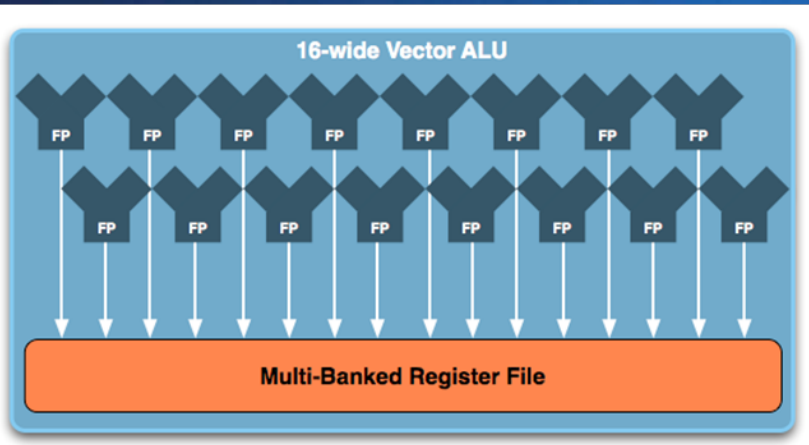
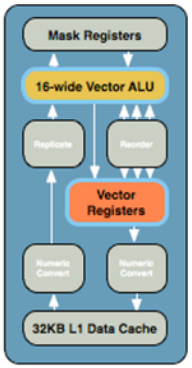


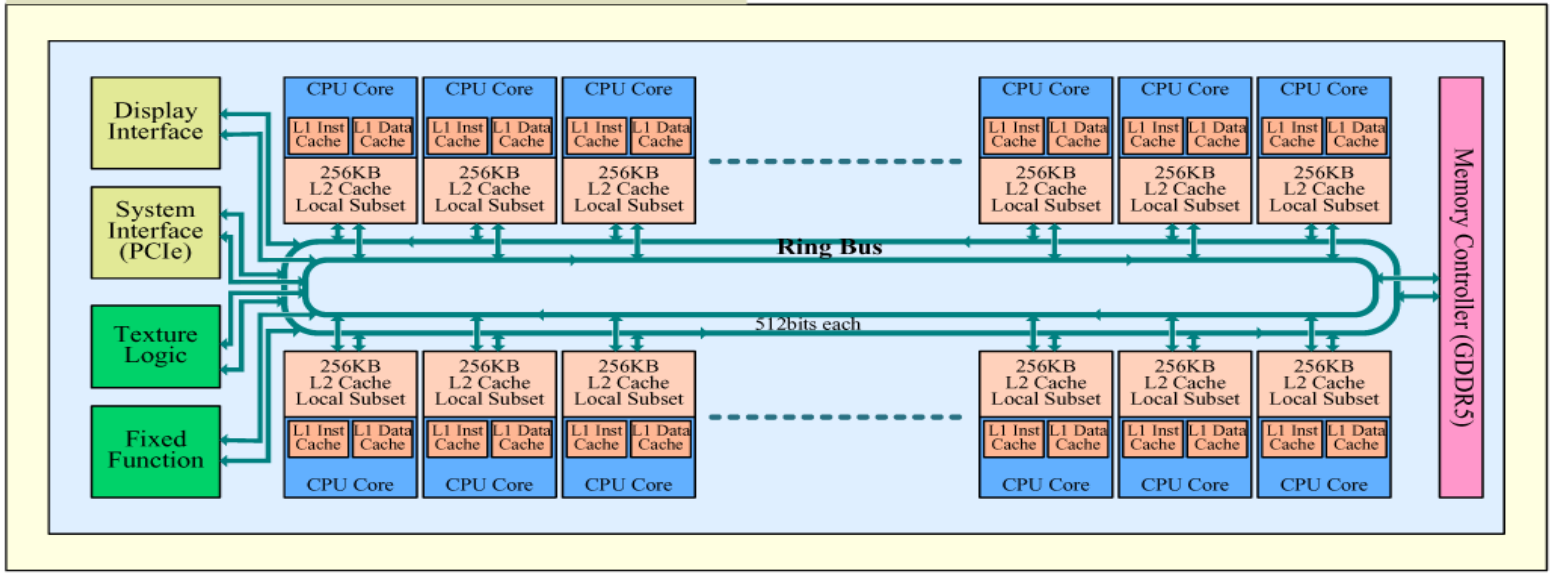


Intel Larrabee架构





Larrabee Block Diagram



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GPU技术路线的分析

软件：

硬件	Nvidia(GT200)	AMD(RV770)	Intel(Larrabee)
X86	否	否	是
Cg	是	是	是
HLSL	是	是	是
ATI Stream	否	是	否
CUDA	是	否	否
OpenCL	是	是	是

AMD Stream computing

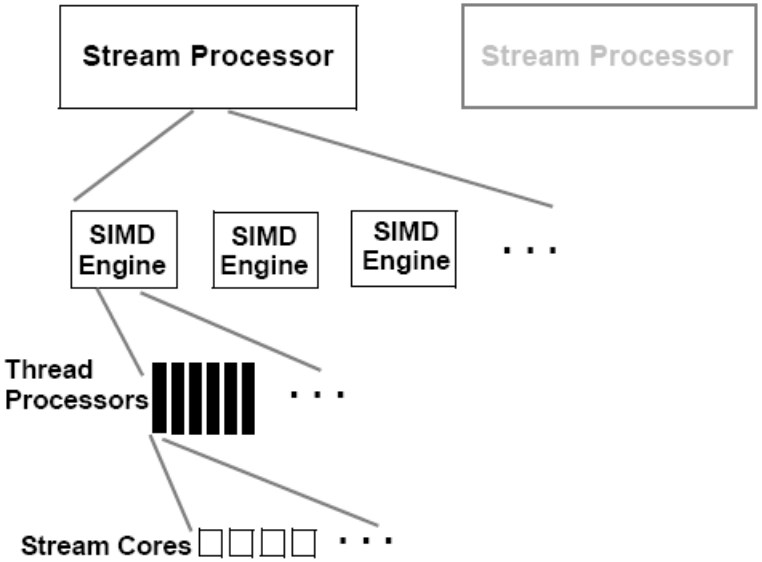


Figure 1.8 Generalized Stream Processor Structure

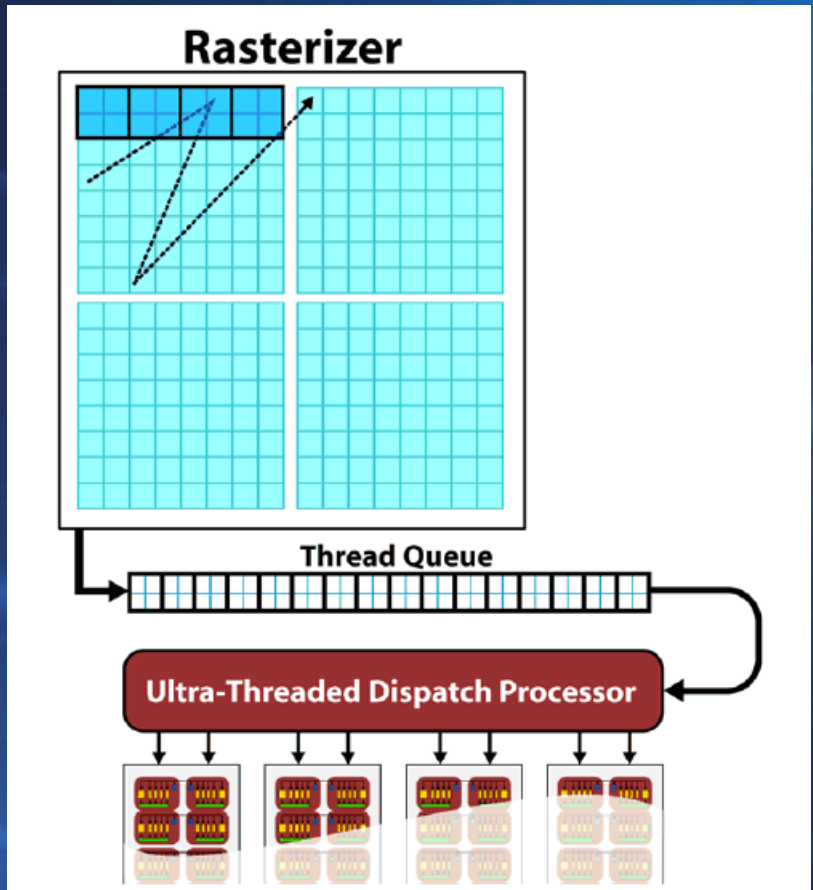
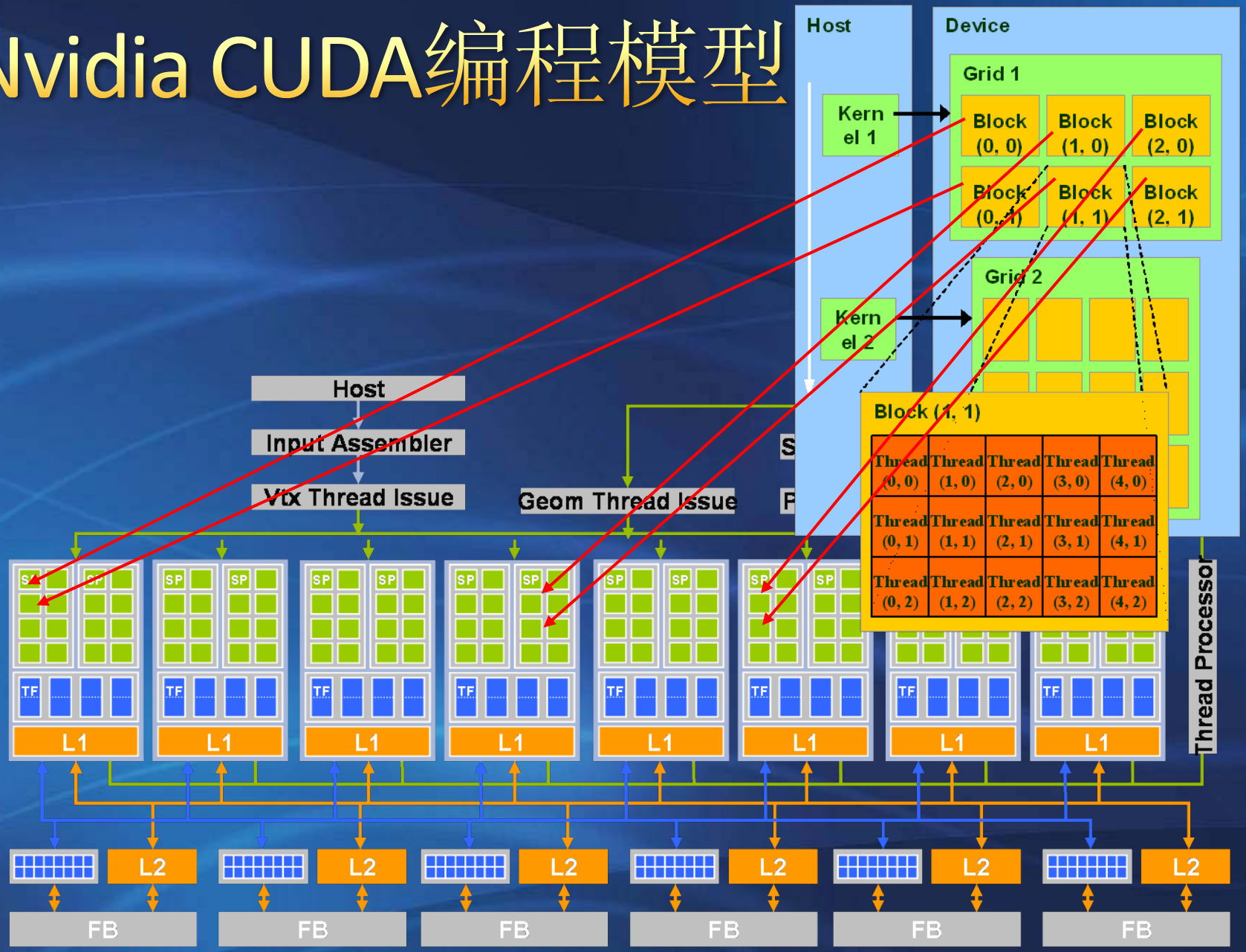
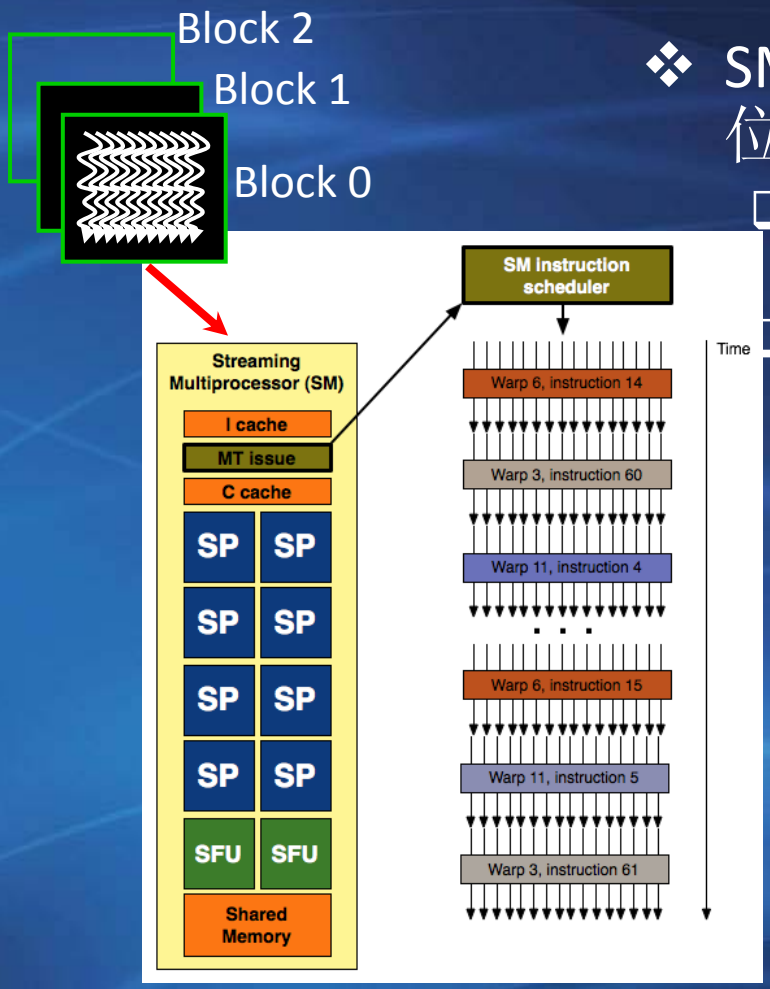


Figure 1.10 Rasterization of Threads to SIMD Engines

Nvidia CUDA编程模型



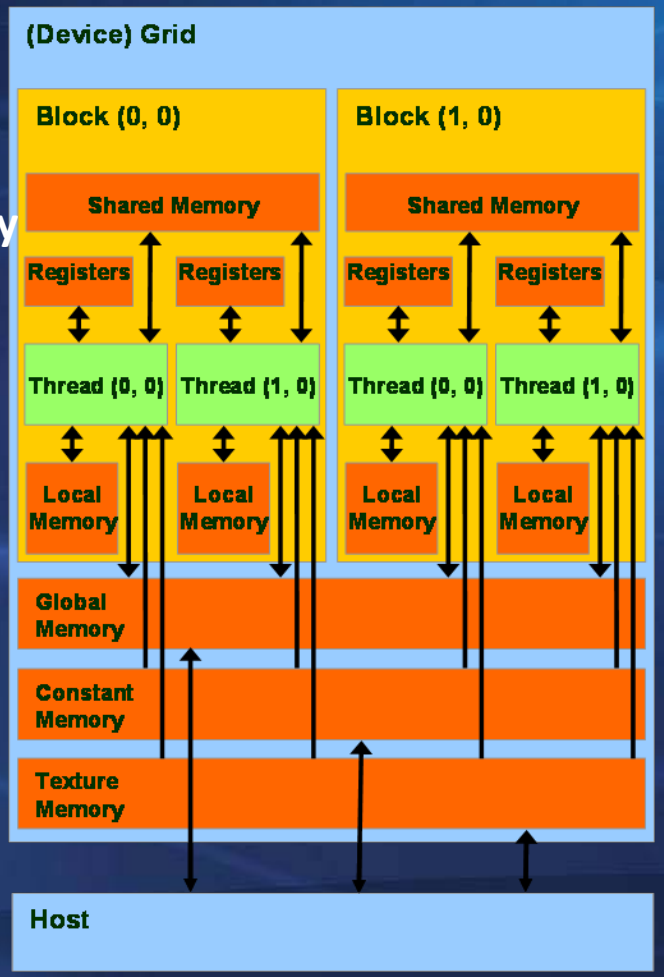
CUDA线程执行模型



- SM内以(warp即32 threads)为单位并行执行
  - Warp(32 threads)内线程执行同一条指令
  - Half-warp(16 threads)是存储操作的基本单位

CUDA 内存模型

- R/W per-thread registers
  - 1-cycle latency
- R/W per-thread local memory
  - Slow – register spilling to global memory
- R/W per-block shared memory
  - 1-cycle latency
  - But bank conflicts may drag down
- R/W per-grid global memory
  - ~500-cycle latency
  - But coalescing accessing could hide latency
- Read only per-grid constant and texture memories
  - ~500-cycle latency
  - But cached



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GPU应用兴趣

- 09.3.2 发布浪潮倚天桌面超算，Intel Nehalem+ Tesla GPU架构，国内客户表现出对GPU的极大兴趣

- 传统HPC领域：生物信息、遥感、计算化学、图像处理、天文研究、分子动力学、CAE、地震勘探、计算机体系研究、……

- 新应用领域： 3G 、视频监控、网络安全、地图引擎、特种电影……

GPU应用开发合作模式

- 联合团队：客户应用团队+浪潮GPU开发团队
- 开发平台：浪潮倚天桌面超算、浪潮GPU集群
- 开发组织：算法并行化设计分析、移植
- 注意事项：热点定位、细节优化
- 案例：中科院基因组所+浪潮生物信息GPU开发

GPU应用优化体会

- 项目并行性分析
  - 热点问题定位
  - 寻找数据并行性，减少数据之间的依赖性
  - 设计相应的并行算法
- 程序优化策略
  - 多的计算时间来隐藏内存访问延时
  - 合理分配线程和内存
  - 多用片上寄存器
  - 全局内存访问瓶颈的优化

QA?