Analysis Report

kernelSMAx(float*, float*, float*, int)

|	
Duration	2.09 ms (2,090,488 ns)
Grid Size	[128,128,1]
Block Size	[32,32,1]
Registers/Thread	12
Shared Memory/Block	4 KiB
Shared Memory Executed	96 KiB
Shared Memory Bank Size	4 B

[0] GeForce GTX 1060 6GB	
GPU UUID	GPU-eb2e304c-810c-cf47-9ddc-b9f1ccdb795a
Compute Capability	6.1
Max. Threads per Block	1024
Max. Threads per Multiprocessor	2048
Max. Shared Memory per Block	48 KiB
Max. Shared Memory per Multiprocessor	96 KiB
Max. Registers per Block	65536
Max. Registers per Multiprocessor	65536
Max. Grid Dimensions	[2147483647, 65535, 65535]
Max. Block Dimensions	[1024, 1024, 64]
Max. Warps per Multiprocessor	64
Max. Blocks per Multiprocessor	32
Half Precision FLOP/s	34.17 GigaFLOP/s
Single Precision FLOP/s	4.374 TeraFLOP/s
Double Precision FLOP/s	136.68 GigaFLOP/s
Number of Multiprocessors	10
Multiprocessor Clock Rate	1.708 GHz
Concurrent Kernel	true
Max IPC	6
Threads per Warp	32
Global Memory Bandwidth	192.192 GB/s
Global Memory Size	5.935 GiB
Constant Memory Size	64 KiB
L2 Cache Size	1.5 MiB
Memcpy Engines	2
PCIe Generation	2
PCIe Link Rate	5 Gbit/s
PCIe Link Width	16

1. Compute, Bandwidth, or Latency Bound

The first step in analyzing an individual kernel is to determine if the performance of the kernel is bounded by computation, memory bandwidth, or instruction/memory latency. The results below indicate that the performance of kernel "kernelSMAx" is most likely limited by instruction and memory latency. You should first examine the information in the "Instruction And Memory Latency" section to determine how it is limiting performance.

1.1. Kernel Performance Is Bound By Instruction And Memory Latency

This kernel exhibits low compute throughput and memory bandwidth utilization relative to the peak performance of "GeForce GTX 1060 6GB". These utilization levels indicate that the performance of the kernel is most likely limited by the latency of arithmetic or memory operations. Achieved compute throughput and/or memory bandwidth below 60% of peak typically indicates latency issues.
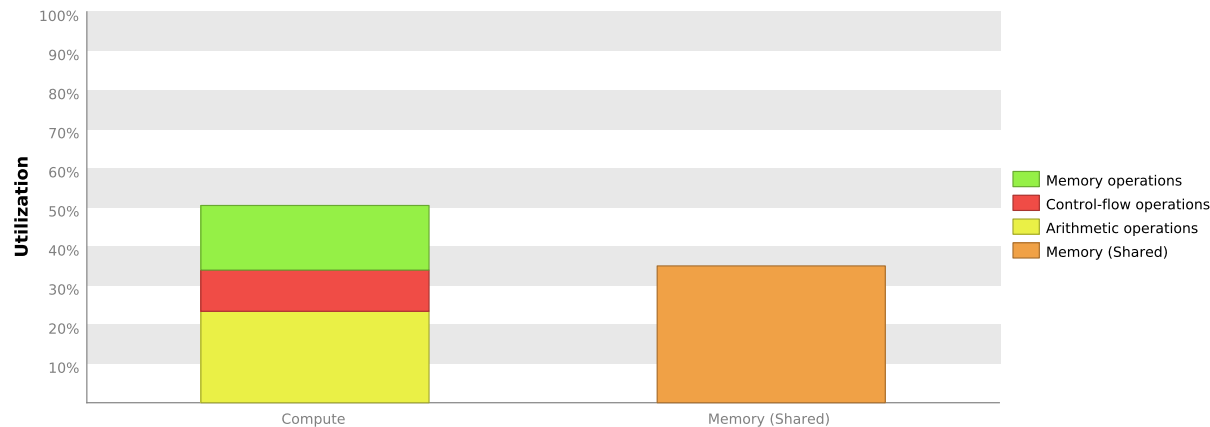
2. Instruction and Memory Latency

Instruction and memory latency limit the performance of a kernel when the GPU does not have enough work to keep busy. The performance of latency-limited kernels can often be improved by increasing occupancy. Occupancy is a measure of how many warps the kernel has active on the GPU, relative to the maximum number of warps supported by the GPU. Theoretical occupancy provides an upper bound while achieved occupancy indicates the kernel's actual occupancy.
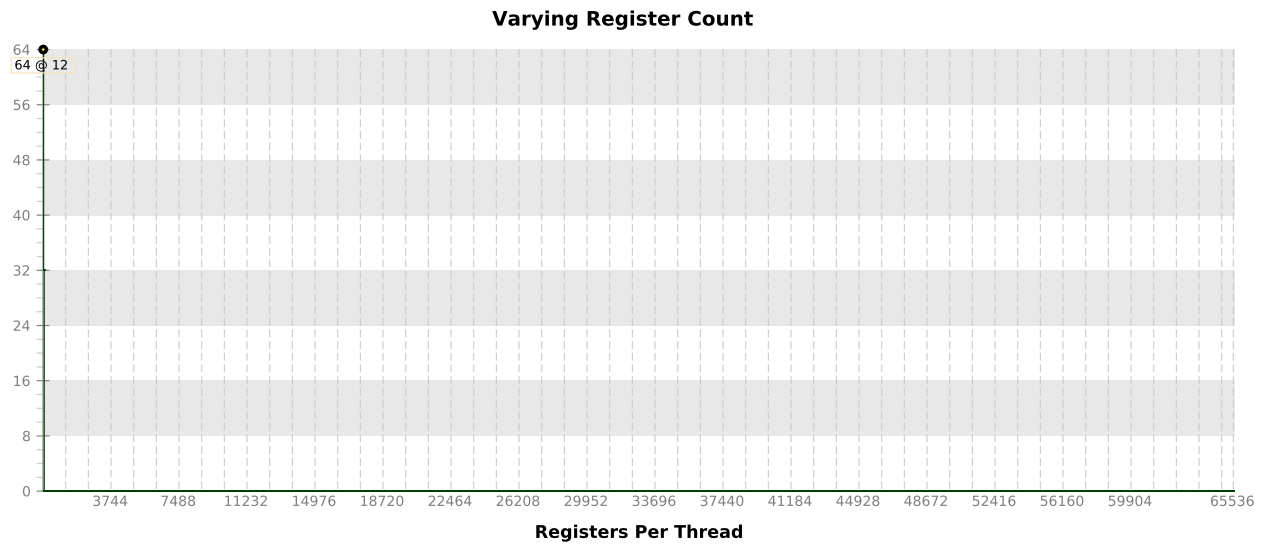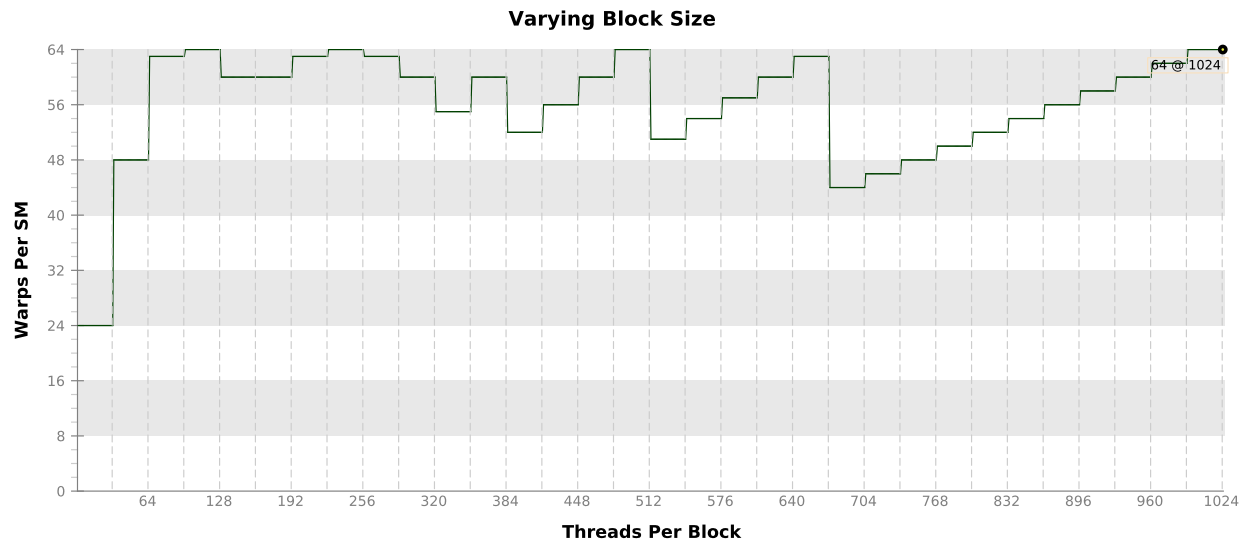
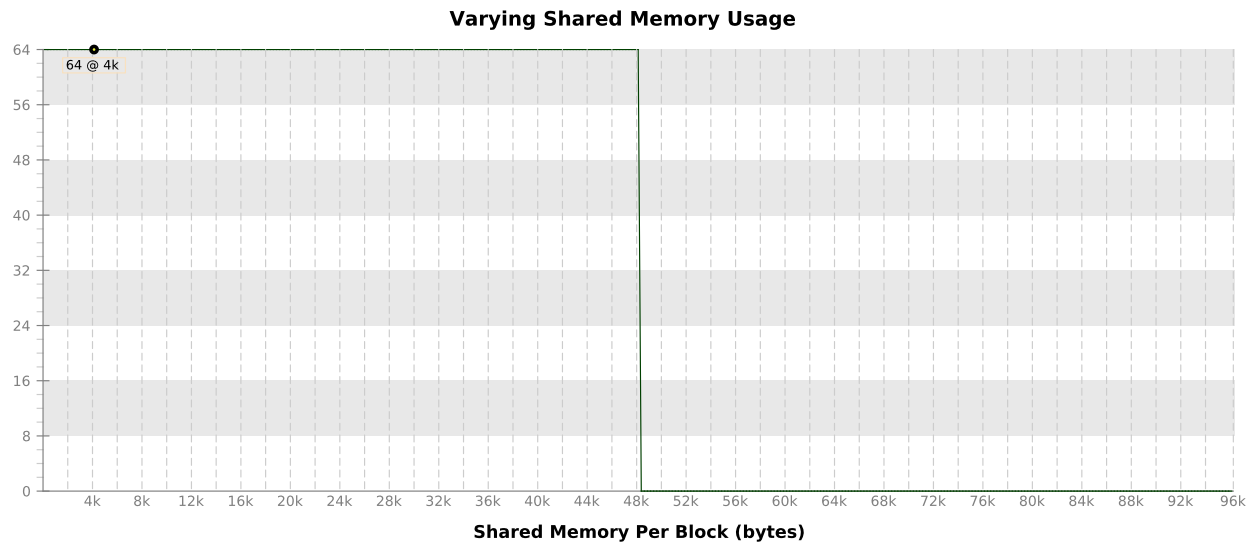## 2.1. Occupancy Is Not Limiting Kernel Performance

The kernel's block size, register usage, and shared memory usage allow it to fully utilize all warps on the GPU.

Variable	Achieved	Theoretical	Device Limit	Grid Size: [128,128,1] (16384 blocks) Block Size: [32,
Occupancy Per SM				
Active Blocks		2	32	
Active Warps	59.83	64	64	
Active Threads		2048	2048	
Occupancy	93.5%	100%	100%	
Warps				
Threads/Block		1024	1024	
Warps/Block		32	32	
Block Limit		2	32	
Registers				
Registers/Thread		12	65536	
Registers/Block		16384	65536	
Block Limit		4	32	
Shared Memory				
Shared Memory/Block		4096	98304	
Block Limit		24	32	

2.2. Occupancy Charts

The following charts show how varying different components of the kernel will impact theoretical occupancy.

Varying Block Size

Y-axis: **Warps Per SM** (0, 8, 16, 24, 32, 40, 48, 56, 64)

X-axis: **Threads Per Block** (64, 128, 192, 256, 320, 384, 448, 512, 576, 640, 704, 768, 832, 896, 960, 1024)

64 @ 1024

Varying Register Count

Y-axis: (0, 8, 16, 24, 32, 40, 48, 56, 64)

X-axis: **Registers Per Thread** (3744, 7488, 11232, 14976, 18720, 22464, 26208, 29952, 33696, 37440, 41184, 44928, 48672, 52416, 56160, 59904, 65536)

64 @ 12

Varying Shared Memory Usage

2.3. Multiprocessor Utilization

The kernel's blocks are distributed across the GPU's multiprocessors for execution. Depending on the number of blocks and the execution duration of each block some multiprocessors may be more highly utilized than others during execution of the kernel. The following chart shows the utilization of each multiprocessor during execution of the kernel.
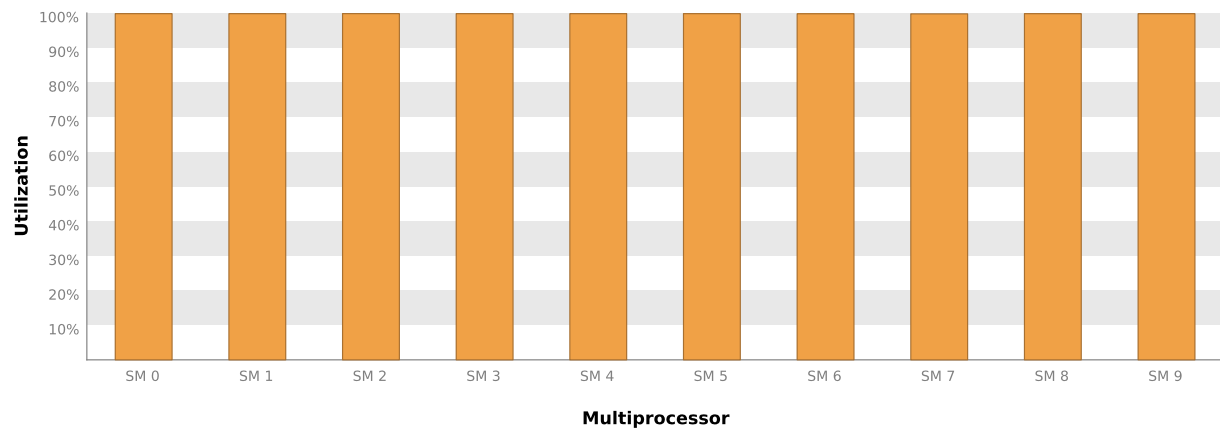
3. Compute Resources

GPU compute resources limit the performance of a kernel when those resources are insufficient or poorly utilized. Compute resources are used most efficiently when all threads in a warp have the same branching and predication behavior. The results below indicate that a significant fraction of the available compute performance is being wasted because branch and predication behavior is differing for threads within a warp.

3.1. Low Warp Execution Efficiency

Warp execution efficiency is the average percentage of active threads in each executed warp. Increasing warp execution efficiency will increase utilization of the GPU's compute resources. The kernel's warp execution efficiency of 68% is less than 100% due to divergent branches and predicated instructions. If predicated instructions are not taken into account the warp execution efficiency for these kernels is 70.3%.

Optimization: Reduce the amount of intra-warp divergence and predication in the kernel.

3.2. Divergent Branches

Compute resource are used most efficiently when all threads in a warp have the same branching behavior. When this does not occur the branch is said to be divergent. Divergent branches lower warp execution efficiency which leads to inefficient use of the GPU's compute resources.

Optimization: Each entry below points to a divergent branch within the kernel. For each branch reduce the amount of intra-warp divergence.

3.3. Function Unit Utilization

Different types of instructions are executed on different function units within each SM. Performance can be limited if a function unit is over-used by the instructions executed by the kernel. The following results show that the kernel's performance is not limited by overuse of any function unit.

Load/Store - Load and store instructions for shared and constant memory.
Texture - Load and store instructions for local, global, and texture memory.
Half - Half-precision floating-point arithmetic instructions.
Single - Single-precision integer and floating-point arithmetic instructions.
Double - Double-precision floating-point arithmetic instructions.
Special - Special arithmetic instructions such as sin, cos, popc, etc.
Control-Flow - Direct and indirect branches, jumps, and calls.
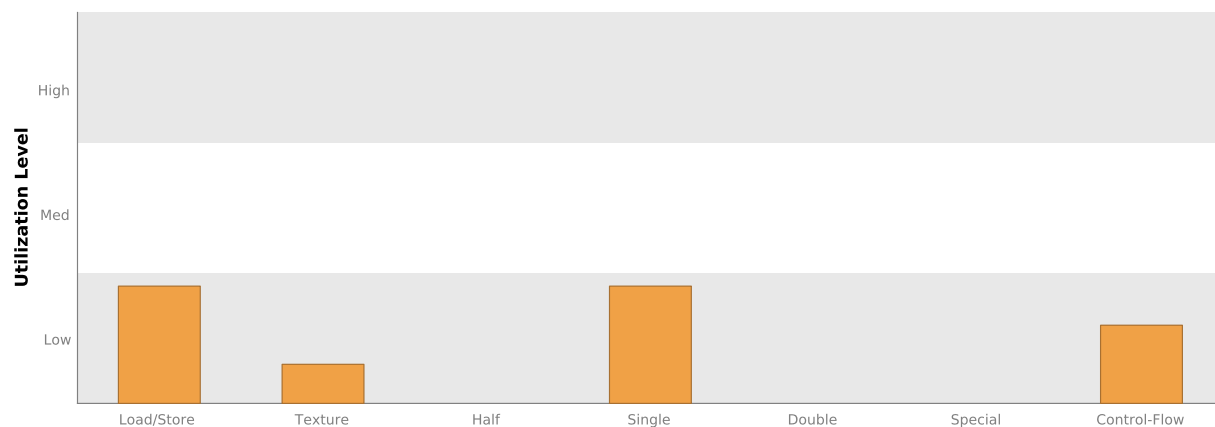

3.4. Instruction Execution Counts

The following chart shows the mix of instructions executed by the kernel. The instructions are grouped into classes and for each class the chart shows the percentage of thread execution cycles that were devoted to executing instructions in that class. The "Inactive" result shows the thread executions that did not execute any instruction because the thread was predicated or inactive due to divergence.
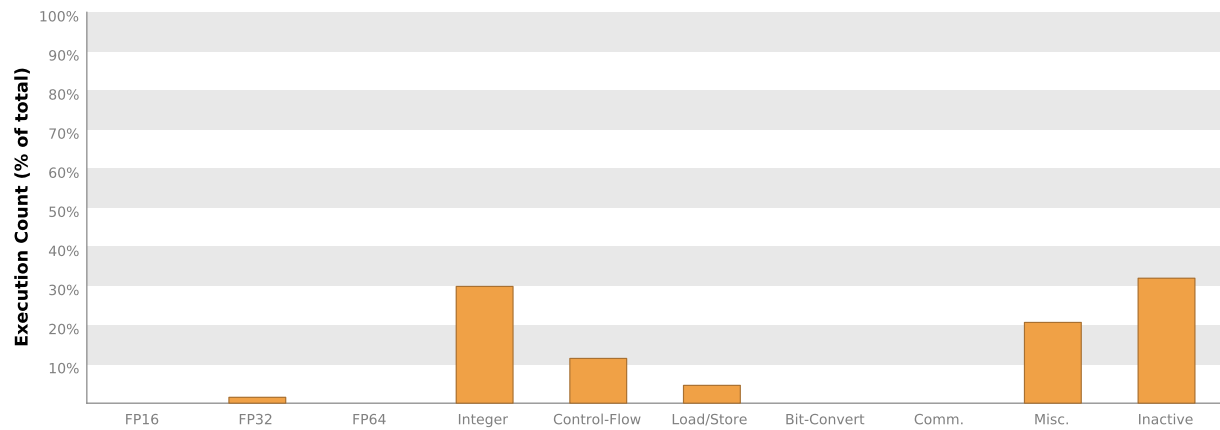
3.5. Floating-Point Operation Counts

The following chart shows the mix of floating-point operations executed by the kernel. The operations are grouped into classes and for each class the chart shows the percentage of thread execution cycles that were devoted to executing operations in that class. The results do not sum to 100% because non-floating-point operations executed by the kernel are not shown in this chart.
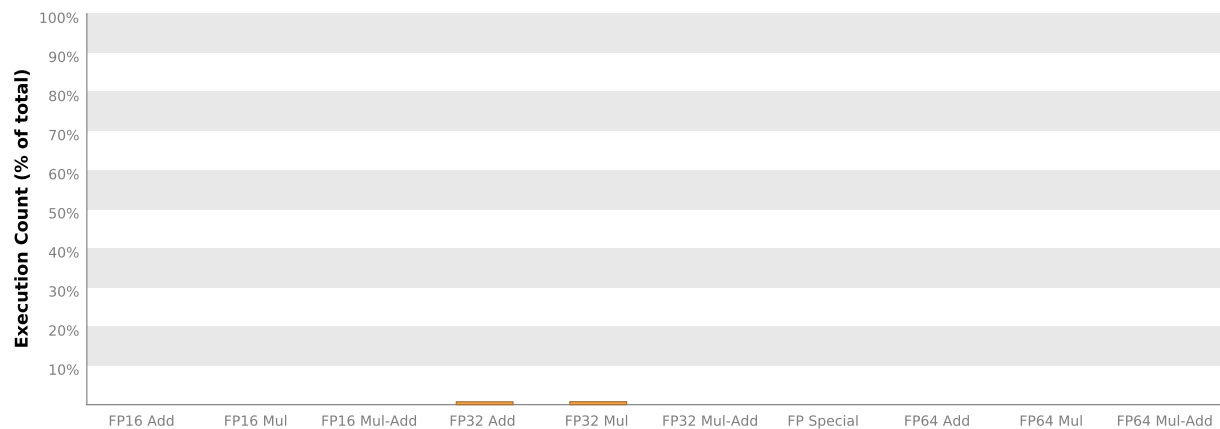
4. Memory Bandwidth

Memory bandwidth limits the performance of a kernel when one or more memories in the GPU cannot provide data at the rate requested by the kernel.

4.1. Memory Bandwidth And Utilization

The following table shows the memory bandwidth used by this kernel for the various types of memory on the device. The table also shows the utilization of each memory type relative to the maximum throughput supported by the memory.

Transactions	Bandwidth	Utilization	
Shared Memory			
Shared Loads	5767168	469.801 GB/s	
Shared Stores	3145728	256.255 GB/s	
Shared Total	8912896	726.056 GB/s	Idle Low Medium High Max
L2 Cache			
Reads	4219096	85.923 GB/s	
Writes	524301	10.678 GB/s	
Total	4743397	96.601 GB/s	Idle Low Medium High Max
Unified Cache			
Local Loads	0	0 B/s	
Local Stores	0	0 B/s	
Global Loads	8388608	85.418 GB/s	
Global Stores	524288	10.677 GB/s	
Texture Reads	4194304	85.418 GB/s	
Unified Total	13107200	181.514 GB/s	Idle Low Medium High Max
Device Memory			
Reads	2149524	43.776 GB/s	
Writes	84355	1.718 GB/s	
Total	2233879	45.494 GB/s	Idle Low Medium High Max
System Memory			
[PCIe configuration: Gen2 x16, 5 Gbit/s]			
Reads	0	0 B/s	Idle Low Medium High Max
Writes	5	101.826 kB/s	Idle Low Medium High Max