# Analysis Report

## matrixMultDevice(float*, float*, float*, int)

| | |
|---|---|
| Duration | 93.339 ms (93,339,293 ns) |
| Grid Size | [ 63,63,1 ] |
| Block Size | [ 32,32,1 ] |
| Registers/Thread | 25 |
| Shared  Memory/Block | 0 B |
| Shared Memory Requested | 96 KiB |
| Shared Memory Executed | 96 KiB |
| Shared Memory Bank Size | 4 B |

[0] GeForce GTX 980

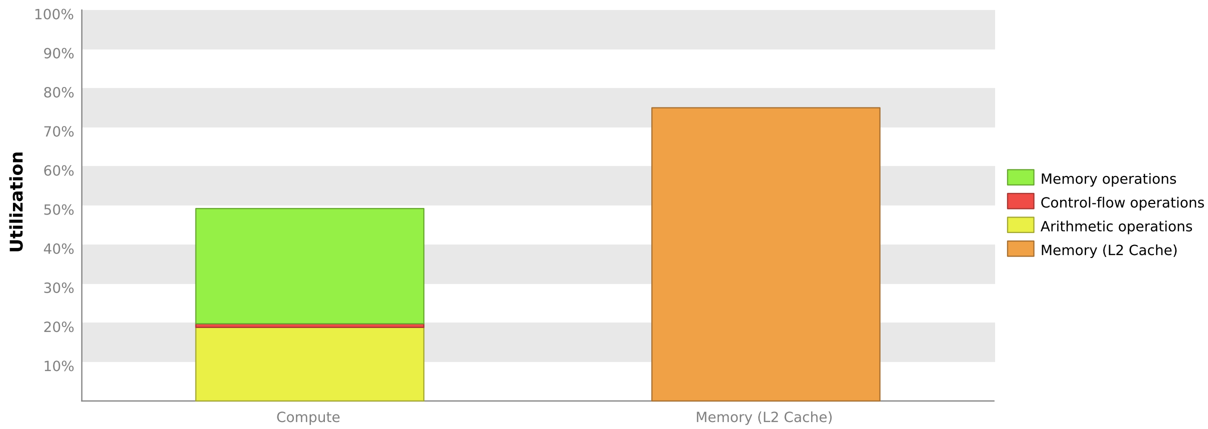
| | |
|---|---|
| GPU UUID | GPU-76f08495-5b58-98e5-fb8d-af6a8ca423be |
| Compute Capability | 5.2 |
| Max. Threads per Block | 1024 |
| Max. Threads per Multiprocessor | 2048 |
| Max. Shared Memory per Block | 48 KiB |
| Max. Shared Memory per Multiprocessor | 96 KiB |
| Max. Registers per Block | 65536 |
| 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 |
| Single Precision FLOP/s | 5.186 TeraFLOP/s |
| Double Precision FLOP/s | 162.048 GigaFLOP/s |
| Number of Multiprocessors | 16 |
| Multiprocessor Clock Rate | 1.266 GHz |
| Concurrent Kernel | true |
| Max IPC | 6 |
| Threads per Warp | 32 |
| Global Memory Bandwidth | 224.32 GB/s |
| Global Memory Size | 3.94 GiB |
| Constant Memory Size | 64 KiB |
| L2 Cache Size | 2 MiB |
| Memcpy Engines | 2 |
| PCIe Generation | 3 |
| PCIe Link Rate | 8 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 "matrixMultDevice" is most likely limited by memory bandwidth. You should first examine the information in the "Memory Bandwidth" section to determine how it is limiting performance.

## 1.1. Kernel Performance Is Bound By Memory Bandwidth

For device "GeForce GTX 980" the kernel's compute utilization is significantly lower than its memory utilization. These utilization levels indicate that the performance of the kernel is most likely being limited by the memory system. For this kernel the limiting factor in the memory system is the bandwidth of the L2 Cache memory.



# 2. 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. The results below indicate that the kernel is limited by the bandwidth available to the L2 cache.

## 2.1. GPU Utilization Is Limited By Memory Bandwidth

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. The results show that the kernel's performance is potentially limited by the bandwidth available from one or more of the memories on the device.

*Optimization: Try the following optimizations for the memory with high bandwidth utilization.*
*Shared Memory - If possible use 64-bit accesses to shared memory and 8-byte bank mode to achieved 2x throughput.*
*L2 Cache - Align and block kernel data to maximize L2 cache efficiency.*
*Unified Cache - Reallocate texture data to shared or global memory. Resolve alignment and access pattern issues for global loads and stores.*
*Device Memory - Resolve alignment and access pattern issues for global loads and stores.*
*System Memory (via PCIe) - Make sure performance critical data is placed in device or shared memory.*

| Transactions | Bandwidth | Utilization | |
|---|---|---|---|
| Shared Memory | | | |
| Shared Loads | 0 | 0 B/s | |
| Shared Stores | 0 | 0 B/s | |
| Shared Total | 0 | 0 B/s | Idle Low Medium High Max |
| L2 Cache | | | |
| Reads | 1254347867 | 473.402 GB/s | |
| Writes | 500006 | 188.707 MB/s | |
| Total | 1254847873 | 473.591 GB/s | Idle Low Medium High Max |
| Unified Cache | | | |
| Local Loads | 0 | 0 B/s | |
| Local Stores | 0 | 0 B/s | |
| Global Loads | 3000000000 | 472.516 GB/s | |
| Global Stores | 500000 | 188.704 MB/s | |
| Texture Reads | 2000000000 | 754.818 GB/s | |
| Unified Total | 5000500000 | 1,227.523 GB/s | Idle Low Medium High Max |
| Device Memory | | | |
| Reads | 35234494 | 13.298 GB/s | |
| Writes | 527588 | 199.116 MB/s | |
| Total | 35762082 | 13.497 GB/s | Idle Low Medium High Max |
| System Memory | | | |
| [ PCIe configuration: Gen3 x16, 8 Gbit/s ] | | | |
| Reads | 0 | 0 B/s | Idle Low Medium High Max |
| Writes | 5 | 1.887 kB/s | Idle Low Medium High Max |

# 3. 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.

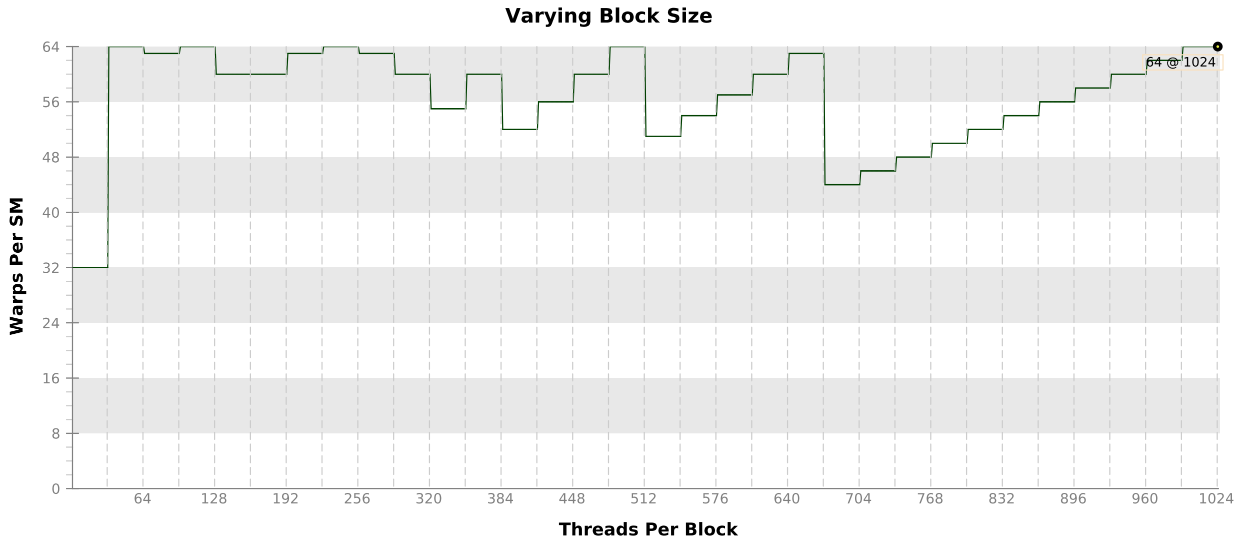
## 3.1. Occupancy Is Not Limiting Kernel Performance

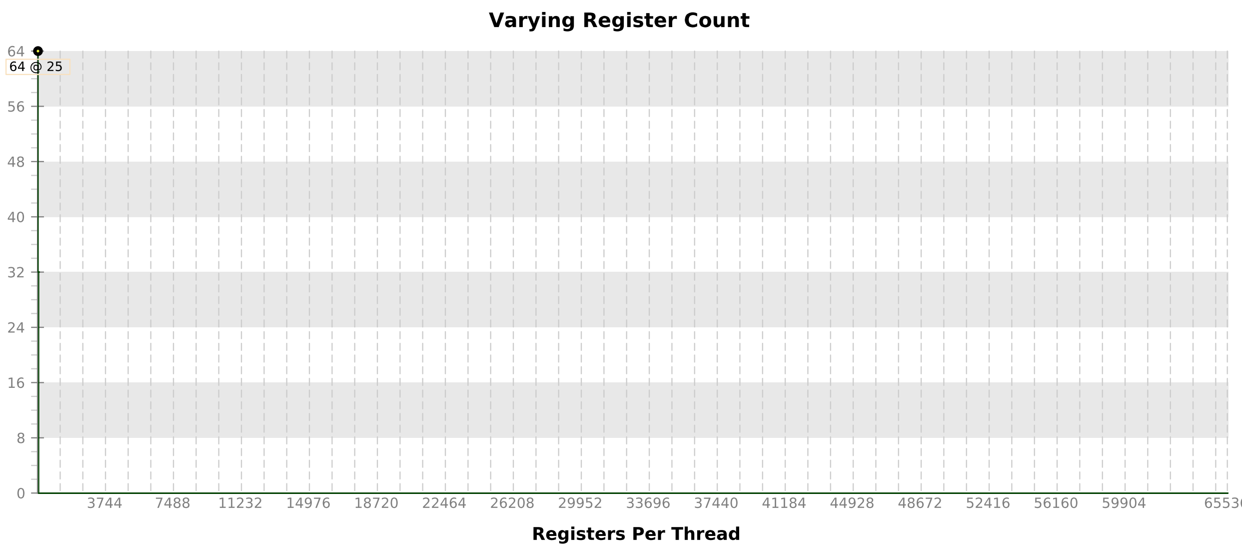
The kernel's block size, register usage, and shared memory usage allow it to fully utilize all warps on the GPU.

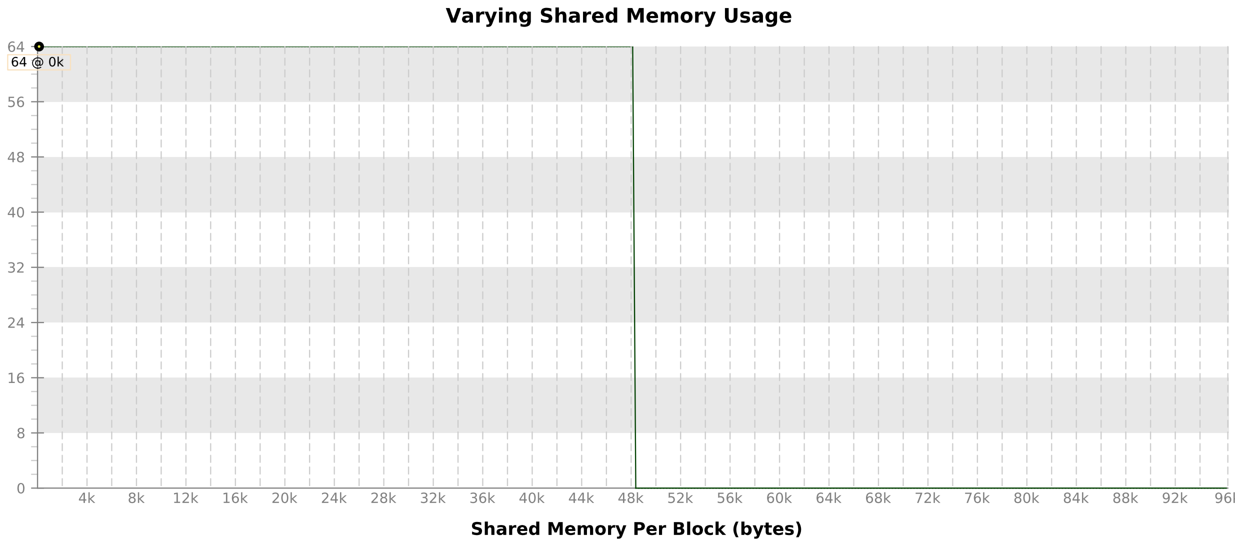
| Variable | Achieved | Theoretical | Device Limit | Grid Size: [ 63,63,1 ] (3969 blocks) Block Size: [ 32,32,1 ] (1024 th |
|---|---|---|---|---|
| Occupancy Per SM | | | | |
| Active Blocks | | 2 | 32 | 0 3 6 9 12 15 18 21 24 27 30 32 |
| Active Warps | 62.02 | 64 | 64 | 0 7 14 21 28 35 42 49 56 6364 |
| Active Threads | | 2048 | 2048 | 0 256 512 768 1024 1280 1536 1792 2048 |
| Occupancy | 96.9% | 100% | 100% | 0% 25% 50% 75% 100% |
| Warps | | | | |
| Threads/Block | | 1024 | 1024 | 0 128 256 384 512 640 768 896 1024 |
| Warps/Block | | 32 | 32 | 0 3 6 9 12 15 18 21 24 27 30 32 |
| Block Limit | | 2 | 32 | 0 3 6 9 12 15 18 21 24 27 30 32 |
| Registers | | | | |
| Registers/Thread | | 25 | 65536 | 0 8192 16384 24576 32768 40960 49152 57344 65536 |
| Registers/Block | | 32768 | 65536 | 0 16k 32k 48k 64k |
| Block Limit | | 2 | 32 | 0 3 6 9 12 15 18 21 24 27 30 32 |
| Shared Memory | | | | |
| Shared Memory/Block | | 0 | 98304 | 0 32k 64k 96k |
| Block Limit | | | 32 | |

## 3.2. Occupancy Charts

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


Varying Block Size
Warps Per SM
Threads Per Block
64 @ 1024
0
8
16
24
32
40
48
56
64
64
128
192
256
320
384
448
512
576
640
704
768
832
896
960
1024


Varying Register Count
Registers Per Thread
64 @ 25
0
8
16
24
32
40
48
56
64
3744
7488
11232
14976
18720
22464
26208
29952
33696
37440
41184
44928
48672
52416
56160
59904
65536


Varying Shared Memory Usage
64 @ 0k
64
56
48
40
32
24
16
8
0
4k
8k
12k
16k
20k
24k
28k
32k
36k
40k
44k
48k
52k
56k
60k
64k
68k
72k
76k
80k
84k
88k
92k
96k
Shared Memory Per Block (bytes)

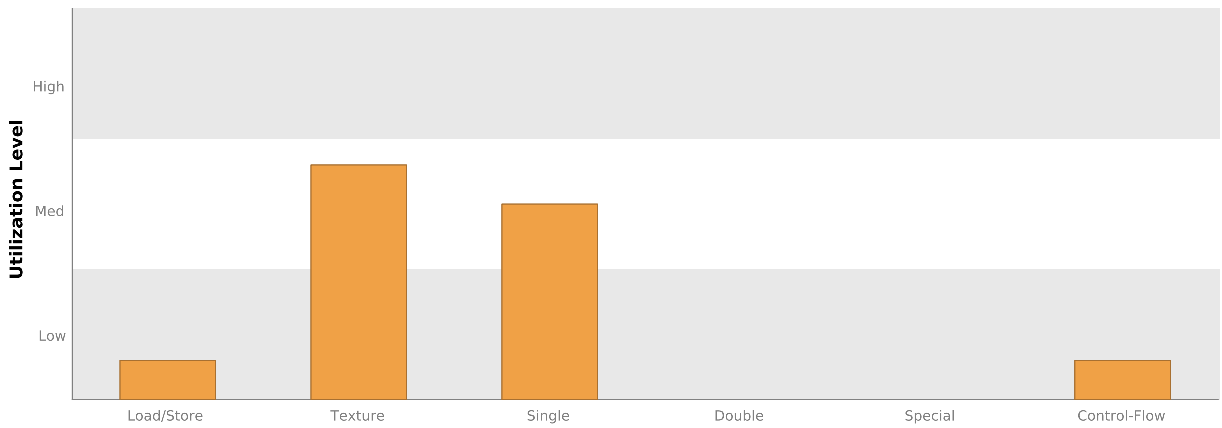
# 4. Compute Resources

GPU compute resources limit the performance of a kernel when those resources are insufficient or poorly utilized.

## 4.1. Function Unit Utilization

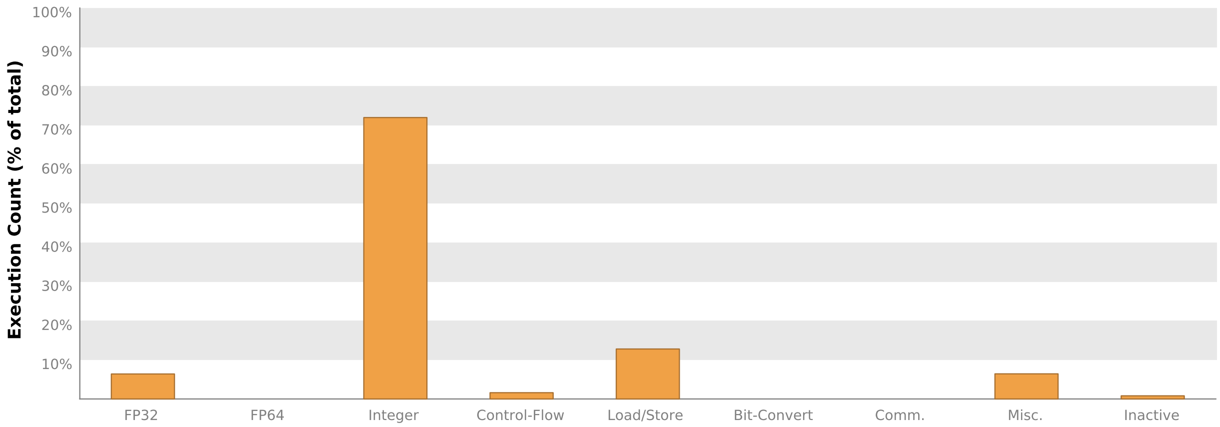
Different types of instructions are executed on different function units within each SM. Performance can be limited if a function unit is over-used by the instructions executed by the kernel. The following results show that the kernel's performance is not limited by overuse of any function unit.

Load/Store - Load and store instructions for shared and constant memory.
Texture - Load and store instructions for local, global, and texture memory.
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.




## 4.2. 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.




### 4.3. 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.