

## 1 Overview

**1.1 Location** `$<AMDAPPSDKSamplesInstallPath>\samples\opencl\cl\1.x`

**1.2 How to Run** See the *Getting Started* guide for how to build samples. You first must compile the sample.

Use the command line to change to the directory where the executable is located. The pre-compiled sample executable is at

`$<AMDAPPSDKSamplesInstallPath>\samples\opencl\bin\x86\` for 32-bit builds, and  
`$<AMDAPPSDKSamplesInstallPath>\samples\opencl\bin\x86_64\` for 64-bit builds.

Type the following command(s).

1. `RadixSort`  
Runs with default option `x = 8192`.
2. `RadixSort -h`  
This prints the help file.

**1.3 Command Line Options** Table 1 lists, and briefly describes, the command line options.

**Table 1 Command Line Options**

Short Form	Long Form	Description
-h	--help	Shows all command options and their respective meaning.
	--device	Devices on which the program is to be run. Acceptable values are <code>cpu</code> or <code>gpu</code> .
-q	--quiet	Quiet mode. Suppresses all text output.
-e	--verify	Verify results against reference implementation.
-t	--timing	Print timing.
	--dump	Dump binary image for all devices.
	--load	Load binary image and execute on device.
	--flags	Specify compiler flags to build the kernel.
-p	--platformId	Select platformId to be used (0 to N-1, where N is the number of available platforms).
-d	--deviceId	Select deviceId to be used (0 to N-1, where N is the number of available devices).
-v	--version	AMD APP SDK version string.
-x	--count	Element count.
-i	--iterations	Number of iterations for kernel execution.

## 2 Introduction

Radix-based sorting algorithms treat keys as multi-digit numbers in which each digit is an integer with a value ranging from 0 to  $m$ , where  $m$  is the radix. A 32-bit integer, for example, could be treated as a 4-digit number with radix  $m = 2^{32/4} = 2^8 = 256$ . Radix sort works by breaking keys into digits and sorting one digit at a time, starting with the *least* significant digit. The radix  $m$  is usually chosen to minimize the running time; it is highly dependent on the implementation and the number of keys being sorted.

The Radix Sort algorithm is divided into 3 phases:

1. Calculate the histogram of an unsorted array.
2. Prescan the histogram bins.
3. Rank and permute to keys to get a sorted array.

See reference [1] for more details on serial and parallel Radix Sort algorithms.

## 3 Implementation Details

The implemented Radix sort breaks keys (32 integers) into 8-bit digits and sorts one 8-bit digit at a time, starting with the least significant digit. It loops four times to complete sorting. In each  $i^{\text{th}}$  loop, the following three phases sort the input array using  $i^{\text{th}}$  8-bit digit.

1. Calculate histogram bins.

The input array is divided into blocks of  $N * M$  elements. Where  $M$  is the radix ( $M$  is 256 for an 8-bit digit), and  $N$  is the number of work-items in a block. In this case,  $N = 16$ . Each work-item calculates its histogram bin from the allotted 256 elements and passes this histogram to next phase.

2. Prescan histogram bins.

In this phase the histogram bins are prescanned column-wise, where histogram bins are arranged in the following way.

There are  $B * N$  histogram bins, where  $B$  is the number of blocks, and  $N$  is the number of work-items in a block. Histogram bins are arranged such that the  $0^{\text{th}}$  block bin comes first, and the  $(B - 1)^{\text{th}}$  block comes last. Each block's histogram bins are arranged so that the  $0^{\text{th}}$  work-item bin comes first, and  $(N - 1)^{\text{th}}$  work-item bin comes last.

The prescanned histogram is passed to next phase.

3. Rank and permute keys to get the sorted array.

Eack work-item permutes the allotted 256 elements by using its prescanned histogram bins.

## 4 References

1. Marcho Zagher and Guy E. Blelloch. "Radix Sort For Vector Multiprocessor." in: *Conference on High Performance Networking and Computing*, pp. 712-721, 1991.
2. Guy E. Blelloch, *Prefix Sums and Their Applications*, School of Computer Science, Carnegie Mellon University, Pittsburgh, 1990.

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