

BROOK+ SAMPLE

Bitonic Sort

1 Introduction

Sorting is a fundamental problem in computing. We illustrate a parallel bitonic sort on an ATI Stream processor using Brook+. A bitonic sort is a data-independent sorting algorithm, where the order of comparison operations does not depend on the input. This makes it a candidate for acceleration by data-parallel implementation.

A *bitonic sequence* is a juxtaposition of two monotonic sequences: one ascending, the other descending. It remains bitonic if it is split anywhere and the two parts are interchanged¹. Alternatively, a sequence of numbers is bitonic if it has at most one local maximum or one local minimum.

A one-dimensional comparator network, \mathbf{B}_n , for a list of n elements, where $n \in \mathbf{N}$, can be defined as a sequence of comparison operations. For example, define \mathbf{B}_n as the following sequence of comparisons: $\mathbf{B}_n = [0 : n/2] [1 : n/2+1] \dots [n/2-1 : n-1]$.

Comparator Network shows a diagram of \mathbf{B}_n for $n = 8$.

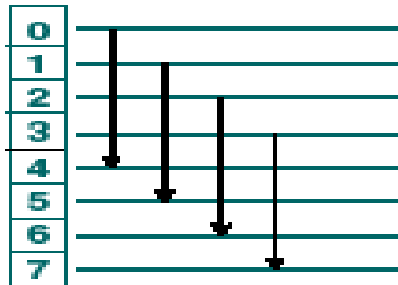


Figure 1

Figure 1 Comparator Network \mathbf{B}_n for $n = 8$

If $\mathbf{a} = a_0, a_1, \dots, a_n$ is a bitonic sequence, then the application of \mathbf{B}_n to \mathbf{a} produces two subsequences: $\mathbf{b} = b_0, b_1, \dots, b_{n/2-1}$, and $\mathbf{c} = c_0, c_1, \dots, c_{n/2-1}$ so that all $b_i \leq \text{all } c_i$ and both \mathbf{b} and \mathbf{c} are bitonic sequences. This forms the basis of an iterative algorithm for a bitonic sort.

¹Batcher, K.E.: "Sorting Networks and their Applications". *Proc. AFIPS Spring Joint Comput. Conf.*, Vol. 32, 307-314 (1968).

2 Bitonic Sorting with Brook+

Figure 2 The bitonic sorting network used for the Brook+ implementation is made up of $\log(n)$ stages, the input array.

shows the process diagrammatically.

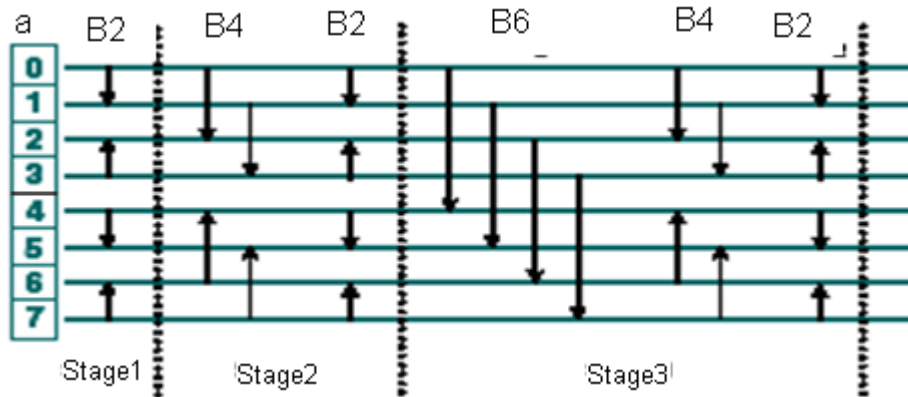


Figure 2 Bitonic Sorting Based on the B_n Comparator Networks (Input Sequence **a** has Length 8 and Requires $\log(8) = 3$ Stages for Sorting)

Figure 2

In **Figure 2**, the span of each arrow shows the elements that are compared; the direction indicates whether to sort in ascending or descending order. The i th stage is composed of i steps, and each step is an application of the comparator network, B_n . At the end of stage i , every sub-sequence of length 2^i is sorted. During the first stage, sub-sequences of length 2 are sorted alternately in ascending and descending order. At the end of stage 1, **a(0-1)** and **a(4-5)** are sorted in ascending order, whereas **a(2-3)** and **a(6-7)** are sorted in descending order. Note that this results in two sub-sequences of length 4 each (**a(0-3)** and **a(4-7)**) both of which are bitonic. These bitonic sub-sequences are the input to the next stage.

Contact

**Advanced Micro Devices, Inc.
One AMD Place**

P.O. Box 3453

Sunnyvale, CA, 94088-3453

Phone: +1.408.749.4000

**For Stream Computing:
URL: www.amd.com/stream**

Questions: streamcomputing@amd.com

Developing: streamdeveloper@amd.com

Forum: www.amd.com/streamdevforum



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