

1 Introduction

Sorting is a fundamental problem in computing. We illustrate parallel bitonic sort on the stream processor using Brook+. 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, 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 B_n as the following sequence of comparisons: $B_n = [0 : n/2] [1 : n/2+1] \dots [n/2-1 : n-1]$. Figure 1 shows a diagram of B_n for $n = 8$.

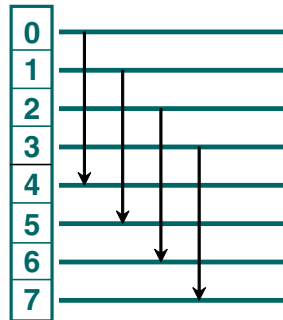


Figure 1 Comparator Network B_n for $n = 8$

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

2 Bitonic Sorting with Brook+

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

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

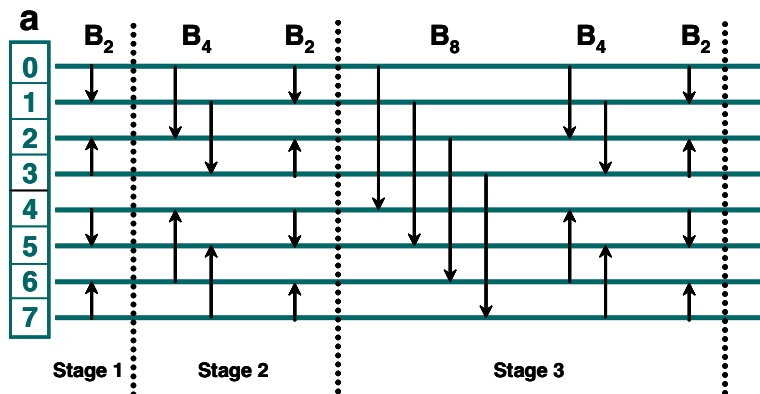


Figure 2 Bitonic Sorting Based on the B_n Comparator Networks (Input Sequence a has Length 8 and Requires $\log(8) = 3$ Stages for Sorting)

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.

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