Decomposing BPC Permutations into Semi-Permutations for Crosstalk Avoidance in Multistage Optical Interconnection Networks

Gennady Veselovsky, Ritu Jain
Department of Computer and Network Engineering
Assumption University
Soi 24, Ramkhamhaeng Road, Huamark
Bangkok 10240, Thailand [1]

Abstract **-** *This paper introduces a simple O(N) algorithm that decomposes BPC (bit-permute-complement) permutations into semi-permutations for avoiding crosstalk when realizing them in N × N optical multistage interconnection networks (OMINs). Crosstalk means that two optical signals, sharing an optical switch, undergo a kind of undesired coupling. A semi-permutation is a partial permutation which meets the requirement for each switch in an input and output stages of the network to be used with only one optical signal at a time. It provides avoiding crosstalk in the first and the last stages of a network and creates the potential for crosstalk-free realization of a semi-permutation, and finally the whole permutation in question. The algorithm is based on employment the periodicity of appearing 1's and 0's in columns of transition matrices for BPC permutations.*

Keywords: *Multistage optical interconnection networks, BPC permutations, semi-permutations, crosstalk avoidance.*

1 Introduction

The vast number of processing elements in massively computers dictates heavy demands for performance of an interconnection network in use. Optical interconnection networks constitute a promising choice in the field because they offer gigabit transmission capacity, very big bandwidth, and low error probability. In what follows we consider hybrid optical multistage interconnection networks (OMINs) using guided wave technology and composed of electronically controlled directional couplers because other types of optical networks are still difficult to implement. In spite of the topological similarity of electronic and optical multistage interconnection networks, the latter cause some specific problems, and the major of them is optical crosstalk. It means that two optical signals, sharing an optical switch, undergo a kind of undesired coupling. The crosstalk reduces essentially signal to noise ratio and so limits the size of a network, whereas the number of processing nodes in modern supercomputers is increasing rapidly. To avoid crosstalk two optical signals should be sent at different time, if they use the same switch. It is called *time domain* approach in distinction from *space domain* approach when crosstalk avoidance is achieved with significant increase of hardware. Crosstalk avoiding problem is discussed in a large number of works, e.g. in [1], [2], [3], [4], [5], [6], to mention only a few. In what follows we have to refer often to the term *switch conflict*. It means using an optical switch (directional coupler) by two input signals at the same time resulting in above mentioned crosstalk. It is noteworthy also that for optical hybrid OMINs under consideration circuit switching rather than packet switching is usually preferred, since with packet switching the address information in each packet must be decoded in each stage that means conversion from optical signal to electronic and so can be very costly.

A permutation is one of the most common communication patterns in parallel computing systems. In the context of a parallel computing system, a permutation means simultaneous transferring of data items between the nodes, with all the destination nodes being different. The term *permutation* can be defined as a request for parallel connection of N sources to N destinations, where $N = 2^n$, with a distinct destination for each of the sources: $S_0 \rightarrow D_{0,} S_1 \rightarrow D_1, \ldots, S_{N-1} \rightarrow D_{N-1}$. Its components will be considered as n-dimensional vectors whose

The research has been funded by Assumption University of Thailand