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On the Oblivious Circuit Switching in Multi-Link Binary Hypercubes

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Abstract

This paper considers the necessary conditions for the existence of oblivious circuit switching in multi-link binary hypercubes. It is also shown that 1(2,3,4,7)-link edge-disjoint, many-one routing exists in the 1(2,3,4,5)-cube. Modular destination graphs are decomposed for the said number of links, where the physical paths are obtained using quasi-dimension-order (cyclic) routing. The basic requirements in obtaining many-one modular destination graphs are discussed. As a result of the combination of two many-one graphs of the same dimension, it directly follows that 1(2,3,4,7)-link, edge-disjoint permutation routing exists in the 2(4,6,8,10)-cube. Also, by combining two, many-one graphs of different dimensions, one can obtain (2,3,4,7)-link edge-disjoint permutation routing in the (3,5,7,9)-cube.

***Keywords**: Circuit switching, oblivious routing, multi-link binary hypercube, modular destination graph, edge-disjoint paths, quasi-dimension-order routing, interconnection networks.*

Introduction

The binary hypercube, or just hypercube, is a subject of intensive research efforts since the publication of the first technical papers on the topic by Sullivan and Bashkow (1977) and Sullivan *et al.* (1977). Since that time, most of the studies in the hypercube topology have been concentrated mainly on the establishment of a conflict-free packet routing (Grammatikakis *et al*. 1998), due to the obstacles on the way of implementing circuit switching.

The rearrangeability of the hypercube in circuit switching mode of operation, as an establishment of edge-disjoint paths, for arbitrary permutations, has been proven by Szymanski (1989) for dimension three. As it has been shown by Lubiw (1990), that the five-dimensional hypercube is not rearrangeable if all paths are restricted to minimal lengths. The rearrangeability of the four-dimensional hypercube is to be verified in the future. In a more recent study by Gu and Tamaki (1997), it has been proven that the hypercube is 2-rearrangeable, and an arbitrary permutation can be routed by two sets of edge disjoint paths. However, it is important to notice that the two sets are different for different permutations, and are to be determined by a central controller during the initialization stage prior to data transmission.

The so-called *e*-cube algorithm (restricted Boolean *n*-cube, Lang (1982) was the basic routing technique being implemented in a number of hypercube hardware configurations due to its simplicity. This is an oblivious-like approach, because it establishes a deterministic dimension-order routing for arbitrary source-destination pairs. The *e*-cube algorithm can be used in establishing edge-disjoint paths for a limited number of permutations. Circuit switching for some basic permutations, has been studied theoretically by Veselovsky and Kupryanova (1991). Dimension scrambling has been used by Lin (1990) in obtaining edge-disjoint paths for the bit reversal permutation. A computational study on the applicability of the dimension-order routing to most common permutations has been performed by Veselovsky and Batovski (2003).