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# ROUTING IN ALL-OPTICAL THREE STAGE-CLOS INTERCONNECTION NETWORKS

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## ABSTRACT

Permutation routing is a popular communication pattern in the interconnection networks. Most of the previously proposed routings algorithms on Multistage Interconnection Networks (MINs) work on 2×2 switches. We considered all-optical rearrangeable permutation routing for Clos Interconnection networks. The signal in the optical switch with the same wavelength will cause the crosstalk problem.In this paper, we proposed algorithm is to rearrange the same wavelength signals, so that no duplicate wavelength in any single middle switch. To avoid wavelength crosstalk, we use wavelength domain approach, and then to solve blocking condition by space domain approach.

**KEYWORDS:** Clos Interconnection Networks, Permutation Routing, Crosstalk

## INTRODUCTION

### CLOS Interconnection Networks

Using small crossbar switches, Charles Clos [1] introduced a type of interconnection network which is extensively studied and applied as a framework for ATM switches because it is economical, regular, scalable, fault-tolerant and highly efficient. Clos three-stage interconnection networks are intended to be used for data communication and parallel computing system [14]. A switching network is composed of one or more switch stages that can create various paths through creating various connections between their inputs and outputs. Clos three-stage network is an example of multistage switching network Figure 1.Clos Interconnection Networks [1] have been gaining attention due to their positional uses in data networks and computing systems. The three-stage Clos network consists of two symmetrical outer stages of rectangular switches, with an inner stage of square switches. The first stage of a three-stage network is called Input stages which contain r switches, each of which has n inputs and m outputs. Each switch is a simple crossbar switch which can realize any mapping of its Input on to its output on a one-to-one basis. The second stage is called middle stage consists of m (r×r) switches, each of which receives exactly one input from each first-stage switch. The third stage is called output stage has r (m×m) switches, each of which receives exactly one Input from each Second stage switch. The number of Inputs to the clos network is N=nr and m≥n. As C (n, m, r) known all possible permutations between Inputs and outputs. A link can be accessed between stages provided it is usable and not engaged.This study presents the permutation routing mechanism in all-optical three stage-clos Interconnection networks. The rest of the paper is organized as follows: Section 2 introduces the previous work on rearrangeable nonblocking Clos networks without considering wavelengths such as Gabow's Edge Coloring, Section 3 presents all-optical Clos interconnection network algorithms to avoid crosstalk and of nonblocking, Section 4 summarizes the paper.

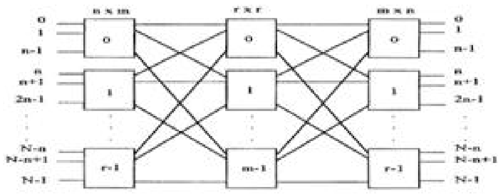


**Fig. 1: A Basic General Clos Interconnection Network**

## ROUTING ALGORITHMS ON REARRANGEABLE CLOS NETWORK

Several rearrangeable routing algorithms have been proposed on developed algorithm. There are three general approaches for designing routing algorithms: Matrix Decomposition, Matching, Edge Coloring.

### Matrix Decomposition

In general, matrix decomposition [8] is not as fast as graph coloring algorithms in the computational complexity. However, the former have advantage of addressing the problem directly, without the need of converting to a graph theoretic problem. Thus, they could be the right choices in many practical applications when the problem size is too large and the communicational complexity has to be balanced by the overhead

### Matching

Slepian and Duguid proved that a three-stage Clos network C (n, m, r) is rearrangeable if $m \geq n$, [5] by using P. Hall's theorem on system on of distinct representative (SDR's).

### Edge Coloring

Many scheduling problems can be viewed as edge coloring problems. The problem to find a minimal edge coloring of a bipartite multigraph is equivalent to maximum matching. Applying edge coloring, to partition the *K*-regular bipartite multigraph into *K* subgraphs, each subgraph will be the setting of a switch in the centre stage. Its application on Clos networks is the input-output mapping is represented by a bipartite multigraph, and the minimal edge coloring is the number of middle stages of switch.

## ROUTING ALGORITHMS OF ALL-OPTICAL CLOS NETWORKS

One of the major problems of optical MINs is optical crosstalk, which occurs when two signal channels interact with each other. In our proposed algorithm, we avoid the crosstalk problem when the same wavelength in the same switch. Hence, we rearrange the same wavelengths in the same switches with node-disjoint routing to achieve it. Then we solve the disturbing of the first non-blocking by space domain approach.

1. **C (n, m, r):** n, m, r are the parameters described the sizes of Clos network and m is maximum degree $\Delta$.

2. **G:** The original mapping with each middle switch and wavelength. $G^m$ ,$G^f$: The result mapping as the output of part 1 input of part 2, and the final output of part 2.

Algorithm 1: Optical Rearrangeable Routing

Input: C (n, m, r), G

Output: $G^f$, and extra middle switch set $\Psi$.

**Begin**

**Part1:** Without considering wavelength

**Part 2:** Considering all optical wavelength

**Algorithm 2: Crosstalk-free and Nonblocking**

**End**

Algorithm 2: Crosstalk-free and Nonblocking

Input: $G^m$ , Δ

Output: $G^{f}$, and extra middle switches set Ψ

**Begin**

**Step 1:** Find the set of switches W which have same wavelength signals in them.

**Step 2:** For u, v ∈W, swap the signals that cause the same wavelength problem in u and v.

Call **Algorithm 3: The same wavelengths crosstalk-free**

**Step 3**: For each middle switch, create a corresponding Paull's matrix

**Step 4**: Call **Function 1: Check_Block(**Gm **,** Δ **)** If no blocking {

**min**Ψ ( extra middle switches set ) =Ψ }

else { create a new switch, and

if $\Psi_i > \Psi_j$ , **min**Ψ = Ψj }

**Step 5:** Repeat Step 1 to Step 4 until there is no blocking and crosstalk in each switches. **Return** $G^f$ and **min** Ψ

**End**

Algorithm 3: The same wavelengths crosstalk-free

The purpose is to change the maximum numbers of the same wavelengths in two middle switches.

Input: C

Output: $C^w$

**Begin**

**do** {

**Step 1:** Fix the row s , to search different wavelengths p , $C_{s,p}=0$; Fix the column t , to search different middle switches q , $C_{q,t}=0$

**Step 2: if** $\exists\, C_{p,t}=0 \Lambda C_{s,q}=0 \Lambda$ maximum $C_{p,q}>0$

swap ( $C_{s,t}$, $C_{p,q}$ )

**Step3: if** $\exists C_{p,t}=0 \Lambda C_{s,q}=0 \Lambda (C_{p,q}=0)$ Repeat Step1, and Step 2, Find the smallest $C_{s,q}$, $C_{p,t}$, and swap them to decrease $C_{s,t}$,

}

**while**( maximum $C_{s,t}>1$ );

**end**

## CONCLUSIONS AND FUTURE WORK

In comparison to previous works avoiding blocking only, our routing messages are on the all-optical Clos network without crosstalk and with free size of switches. However, the worst case is to compute all the combinations to get the solution. We still brainstorm to reduce the computation in an efficient manner.

Our future work is to improve Algorithm 2 such that after second nonblocking rearrangement, we can consider only the wavelength crosstalk on the extra center switches.

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