

# Chapter 16

## Cost Efficient Implementation of Multistage Symmetric Repackable Networks

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### ABSTRACT

*Symmetric rearrangeable networks (SRN) (Chakrabarty, Collier, & Mukhopadhyay, 2009) make efficient use of hardware, but they have the disadvantage of momentarily disrupting the existing communications during reconfiguration. Path continuity is a major issue in some application of rearrangeable networks. Using repackable networks (Yanga, Su, & Pin, 2008) is a solution to the path continuity problem in SRN. These networks provide functionality comparable to that of strict sense no blocking networks (SNB) but with minimum increase in the hardware than SRN. This paper proposes an efficient implementation of multistage symmetric repackable networks requiring optimum hardware cost than the method proposed in the literature. Cost optimization is achieved through the use of minimum number of bypass link(s). Investigated method works for networks built with more than three switching stages and shows promise of scalability.*

### INTRODUCTION

Repackable networks allow the path continuity even though it's built on top of rearrangeable network. Basic structure of these networks contain bypass links, which route requests where paths

need to be rearranged of those requests, one at a time or all together through those bypass links for continuation of the ongoing communication. After the necessary rearrangements, requests through the bypass links are put back into their new rearranged routes hence the term repackable used for these networks. Addition of bypass links increases the hardware cost than a similar size rearrangeable

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network but this provides a performance close to SNB networks (Busi & Pattavina, 1998). Today's high performance communication systems require fast switching so that requested connecting paths can be established quickly. In optical networks, these switches typically require multistage implementation for capacities larger than 16x16. The choice between blocking networks (Wu & Feng, 1980; Lawrie, 1975; Feng, 1974) and rearrangeable (Hwang, Lin, & Lioubimov, 2006; Yeh & Feng, 1992) or strict sense nonblocking (Busi & Pattavina, 1998) networks involve a tradeoff between the complexity of rearrangeable routing and the cost of strict nonblocking networks. In a blocked state, rearranging the connections is the basic operation principle of a rearrangeable network. These rearrangements disrupt the existing communication through the candidate links. But it is possible to imply some efficient method to make rearrangeable network much more efficient, such as modifying the rearrangement process in a blocking state and make rearrangeable networks more effective in high performance communications. Use of repackable method can allow modification in the rearrangement process of the rearrangeable networks. We used most popular rearrangeable network to design our proposed repack method, which is Beneš network. Beneš network is an  $N$  input-output network build with  $2 \times 2$  switching elements (SEs) (Beneš, 1965).

## **RELATED WORK**

Most proposals for repackable networks are based on 3-stage Clos networks. Ackroyd (1979) first introduced the concept of repacking for 3-stage networks. He proposed using one of the middle stage subnetworks for routing all the requests. This is generally termed as packing. If this packing technique results in blocking, the other subnetwork is used to route the blocked request. At a later time, that request is rerouted via the packed subnetwork. Jajszczyk and Jekel (1993) provided

the basic condition for a 3-stage Clos network to be repackable. If  $n$  and  $m$  being the input and output for the each input (output) stage switching elements and  $r$  being the number of switching elements in the input (output) stage} respectively then repackable condition is,  $m \geq 2n - \lceil n / (r - 1) \rceil$  Jajszczyk and Jekel (1993) explained that using a repackable network, it is always possible to establish connecting paths between an input and output. His proposed method routes requests from the less used subnetwork to the most used one before the arrival of a new request.

Schehrer (1999, 2000, 2001, 2007) proposed two method of reswitching in a repackable network (1) sequential (2) simultaneous. The term reswitching is different than rearrangement, as it means putting requests through the bypass network or paths, and put back to rearrangeable network once paths have been rearranged and making the bypass network or paths free for future use. In sequential reswitching paths need to be rearranged are selected sequentially and put through the bypass paths. Once the paths are rearranged in the rearrangeable network they are put back to their new routes and then new set of paths are selected for the reswitching. On the other hand, simultaneous reswitching selects the smallest number of paths needs to be rearranged and then put them to the bypass links or network. Once the paths are rearranged in the rearrangeable network, they are put back to their new routes together.

## **OUR CONTRIBUTION**

As mentioned earlier that most of the repackable works pro-posed in the literature are mainly for 3-stage Clos networks. In this paper we propose repacking method for the Beneš networks which is a very popular symmetric rearrangeable network. In this paper we proposed method that utilizes the basic method of using bypass network

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