Comment on "A New Routing Algorithm for a Class of Rearrangeable Networks"

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Abstract—The original paper presents an efficient algorithm for routing an Omega^{-1} × Omega nonblocking network. This comment presents an extra step required to route an Omega + Omega network.

Index Terms—Multistage interconnection network, MIN, Omega network, rearrangeably nonblocking, perfect shuffle, routing, interconnection.

THE original paper presents a new routing algorithm for a class of rearrangeably nonblocking interconnection networks. Given a desired one-to-one interconnection pattern Π, this efficient algorithm requires $O(N)$ routing steps to set the network switches, and can be applied to any symmetric network layout (symmetric about a virtual center line at the center stage). The Omega^{-1} × Omega is an example of such a network, where Omega^{-1} is a reverse Omega network and is connected to another Omega network by a butterfly pattern (denoted by the "×"). The authors further claim that the algorithm can be applied to an asymmetric network as the Omega + Omega network (the concatenation of two Omega networks). It is proven (Theorem 1) in the paper that an $N \times N$ 2 $\log_2 N$-stage asymmetric Omega + Omega network can always be converted into a symmetric $N \times N$ 2 $\log_2 N$-stage Omega^{-1} × Omega network, through a bit-reversed-order rearrangement of the switching elements (SE) of the first Omega network (first $\log_2 N$ stages). Therefore, the authors suggest that to route an Omega + Omega network, a conversion to an Omega^{-1} × Omega network be applied, on which the routing algorithm is performed, and then convert the SE settings back to the Omega + Omega network. Carrying out this procedure will not fulfill the desired interconnection pattern, unless an extra step is taken.

The inability of the procedure to properly determine the SE's settings arise from the connection between the first SE stage and the input terminals. Two factors have to be compensated for in the conversion, which are:

1) The conversion method of the Omega + Omega network to an Omega^{-1} × Omega network requires rearranging the SEs in each stage of the first Omega network ($\log_2 N$ stages). The input terminals to the network are not rearranged in a similar fashion. Executing the routing algorithm on the Omega^{-1} × Omega network with the desired interconnection patterns completely routes the Omega^{-1} × Omega network, but the results can not be converted back to the Omega + Omega network, since the input terminals are not in sequential order any more.
2) The topology of an Omega network dictates a perfect shuffle before the first SE array. Once again, the switch settings can not be converted back to the Omega + Omega network, as the input terminals were shuffled.

Correcting these problems is relatively simple. Since the input terminals to the converted Omega^{-1} × Omega network are both permuted by a perfect shuffle and rearranged according to the SE relocation, we shall define a new interconnection pattern that compensates for these two effects. An input index $b_{n-1}b_{n-2} \ldots b_1b_0$ (where $n = \log_2 N$) is shuffled $b_{n-2} \ldots b_1b_0b_{n-1}$ (bit rotation to the left) and rearranged according to the SE relocation $b_0b_1 \ldots b_{n-2}b_{n-1}$ (bit reversal of the leftmost $n - 1$ bits), which is equivalent to a bit reversal operation on the input index, before entering the Omega^{-1} × Omega network. Therefore the desired interconnection assignment in the Omega + Omega network, $\Pi(b_{n-1}b_{n-2} \ldots b_1b_0) = j$ (where j is the output terminal), is equivalent to the assignment $\Pi'(b_0b_1 \ldots b_{n-2}b_{n-1}) = j$ in the Omega^{-1} × Omega network.

Routing of an Omega + Omega network is now achieved. For a desired interconnection pattern Π, convert the network to an Omega^{-1} × Omega topology, execute the routing algorithm with the permuted interconnection pattern Π′, and convert the switch settings back to the Omega + Omega network. The connection pattern achieved is the desired pattern Π. For the desired interconnection assignment given in the original paper, the SE settings are shown in Fig. 1.

A similar analysis can be carried out for a conversion of the Omega + Omega network into an Omega × Omega^{-1} network (a symmetric network as well). This time the desired pattern Π would have to be modified on the output side by permuting the destination terminal by a bit reversal of the leftmost n − 1 bits.

$$\Pi = \left\{ \begin{matrix} 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 & 13 & 14 & 15 \\ 7 & 2 & 5 & 15 & 3 & 9 & 12 & 8 & 14 & 0 & 4 & 13 & 6 & 11 & 1 & 10 \end{matrix} \right\}$$

$$\Pi' = \left\{ \begin{matrix} 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 & 13 & 14 & 15 \\ 7 & 14 & 3 & 6 & 5 & 4 & 12 & 1 & 2 & 0 & 9 & 11 & 15 & 13 & 8 & 10 \end{matrix} \right\}$$

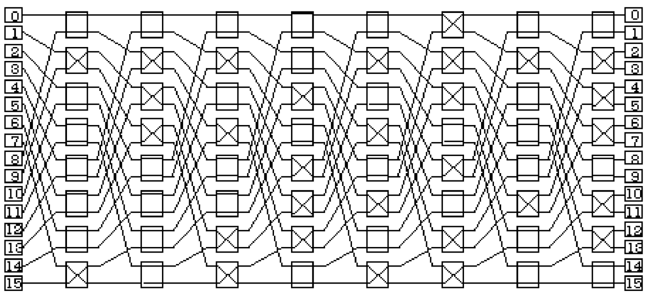

Fig. 1: Top: a desired interconnection assignment and converted form; bottom: completely routed Omega + Omega nonblocking network.

REFERENCES

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