Generalized Connectors

There are several ways to construct these:

- Single crossbar.
- Clos-type generalized connectors.
- Networks called *fanout/concentrators.*
- *Pack/Copy/Permute* networks.

Pack/Copy/Permute Generalized Connectors.

This network described by Ofman[1] and a generalized version described by Thompson[2].

Network is rearrangeable (for generalized connection assignments).

Network has three parts:

- Pack: packs those inputs having requests to consecutive links.
- Copy: fans out (copies) inputs to multiple links.
- Permute: routes to proper output.

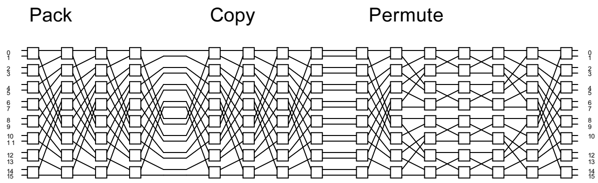
Construction

The pack part is an inverse omega network.

The copy part is an omega network, with cells that can broadcast.

The permute part is (sometimes) a Beneš network.

Straightforward Construction

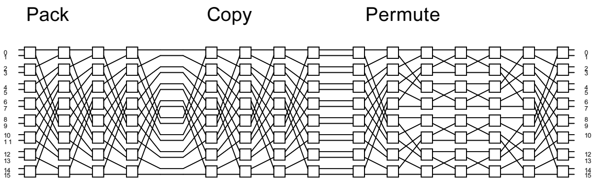


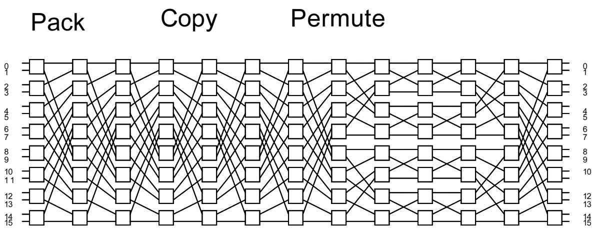
[1] Ju. P. Ofman, "A universal automaton," *Transactions of the Moscow Math Society*, pp. 200-215, 1965.

[2] Clark D. Thompson, "Generalized connection networks for parallel processor intercommunication," *IEEE Transactions on Computers*, vol. 27, no. 12, pp. 1119-1125, December 1978.

Slightly Lower-Cost Version

Stages where parts meet can be removed, eliminating two stages.





Cost

Straightforward version: $4n2^{n-1}$ cells.

Lower-cost version: $(4n-3)2^{n-1}$ cells.

Routing CA Γ

- Route each input having a request from GC inputs (same as pack-part inputs) to consecutive copy-part inputs.

  (Using a packing CA).

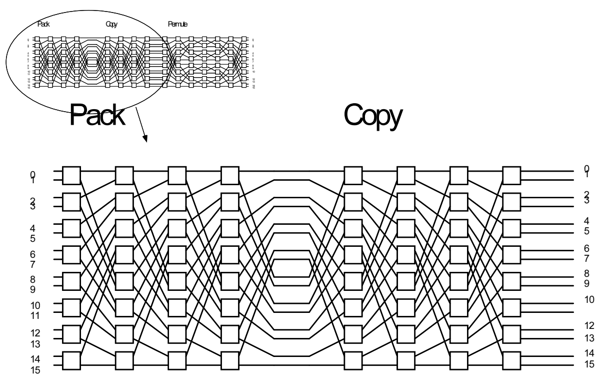
- Route $A = (a, \alpha) \in \Gamma$ at copy-part input to $|\{ (a, \chi) \mid (a, \chi) \in \Gamma \}|$ consecutive copy-part outputs.

  (That is, make needed number of copies using a copy connection assignment.)

- Finally, route $A = (a, \alpha)$ to output α through permute part.

  (Use dummy requests to create a permutation if necessary, then use looping algorithm to route Beneš network.)

- Done.

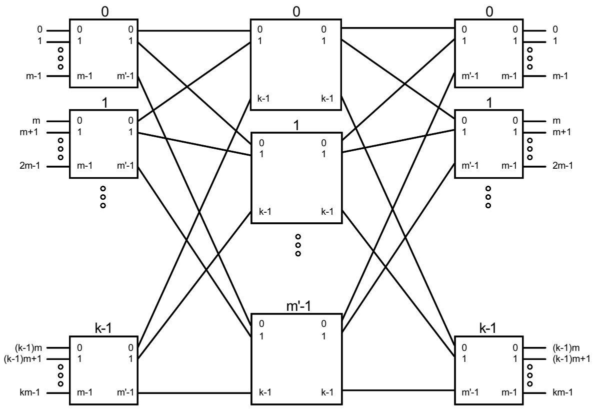


Clos-Type Generalized Connector

Described by Yang and Masson[3].

Is a non-blocking d-limited generalized connector.

Construction



Topology of Clos network in which $m' > (m-1)(x + d^{1/x})$,

where $0 < x \leq \min\{\, m-1, d \,\}$ and $0 < d \leq k$.

(Choice of x determines cost and performance.)

[3] Yuanyuan Yang and Gerald M. Masson, "Nonblocking broadcast switching networks," *IEEE Transactions on Computers*, vol. 40, no. 9, pp. 1005-1015, September 1991.

Cost

The minimum cost of a $2n+1$ stage Clos-type GC is bounded by

$$C(N, 2n+1) = O\left(N^{1+\frac{1}{n+1}} \left(\frac{\log N}{\log\log N} \right)^{\frac{n+2}{2} - \frac{1}{n+1}} \right)$$

To achieve this bound choose:

$$m' = O\left(m \frac{\log k}{\log\log k} \right) \qquad \text{or} \qquad m' > (m-1)(\log_2 k + 2)$$

and at level i choose

$$k = \frac{N^{\frac{i}{i+1}}}{(\log N / \log\log N)^{\frac{i}{2} - \frac{1}{i+1}}}.$$

Derivation of these equations are not covered.

(These equations are not easy to work with.)

Routing Performance

A new request can be routed in $O(mk)$ time.

A connection assignment can be routed in $O(m^2 k)$ time.

(Routing for this network will not be covered.)

Fanout/Concentrate Generalized Connector

Described by Nassimi and Sahni[4]

Construction:

Consists of three stages:

- *Generalizer*. Makes 2^m copies of each input.
- *Concentrator*. Multiplexes (concentrates) inputs (to outputs).
- *Generalized Connector*. An $\frac{N}{2^m}$ generalized connector.

Operation:

Generalizer makes a copy for each of 2^m concentrators.

Concentrator routes active inputs to recursive GC.

Recursive generalized connector completes routing.

[4] David Nassimi and Sartaj Sahni, "Parallel permutation and sorting algorithms and a new generalized connection network," *Journal of the Association for Computing Machinery*, vol. 29, no. 3, pp. 642-667, July 1982.