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\textsuperscript{1} and a generalized version described by Thompson\textsuperscript{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

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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 $\Gamma$

- 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 $|\{(a, \chi) | (a, \chi) \in \Gamma\}|$ consecutive copy-part outputs.

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

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

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

- Done.
Described by Yang and Masson\(^3\).

Is a non-blocking \(d\)-limited generalized connector.

Construction

![Diagram of Clos network](attachment:image.png)

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.)

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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:

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

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\textsuperscript{4}

Construction:

Consists of three stages:

- \textit{Generalizer}. Makes $2^m$ copies of each input.
- \textit{Concentrator}. Multiplexes (concentrates) inputs (to outputs).
- \textit{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.

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