

0.1 CLOS

From [./AE-Specifications-ETH/sections/Clos.tex](#)

0.1.1 Topology set-up (same 200 servers)

Clos fabric 20 racks, each with 10 servers. Every server now owns **four** NIC ports, all cabled to its top-of-rack (ToR) switch, giving $200 \times 4 = 800$ host links. Each ToR uplinks once to *each* of the four spine switches. A pair of core switches terminates the third level.

8-regular mesh The same 200 servers, each equipped with **eight** NIC ports wired into an undirected 8-regular graph. The link count is

$$L_{\text{mesh}} = \frac{200 \times 8}{2} = 800,$$

exactly matching the number of host cables in the Clos system.

0.1.2 Cable inventory

Link class	Clos count	Mesh count
Server–ToR	800	–
ToR–Spine	80	–
Spine–Core	8	–
Server–Server (mesh)	–	800
Total physical links	888	800

Table 1: Cable counts after upgrading each Clos server to four NIC ports. The mesh uses the same 800 cables as data-carrying edges, eliminating the 88 upward cables and the entire switch hierarchy above the racks.

0.1.3 Failure-mode magnitude

Treat each link as an independent four-state component $\Sigma = \{00, 01, 10, 11\}$.

The number of distinct network states is 4^L , so the number of failure patterns is $4^L - 1$.

$$\log_{10}(4^L) = 0.60206 L.$$

Topology	L	Failure modes (order of magnitude)
Clos (4 ports)	888	$\sim 10^{535}$
Mesh (8-regular)	800	$\sim 10^{482}$

Although the Clos now contains more cables, inter-rack traffic is still forced through only 88 uplinks. The mesh distributes both traffic and failure risk across *all* 800 cables.

0.1.4 Path-diversity impact

Clos

- A rack-to-rack flow traverses six vertical hops (Server \rightarrow ToR \rightarrow Spine \rightarrow Core and back down).
- End-to-end success probability is roughly p^6 , where p is the per-link health probability.

Mesh

- Every server has eight one-hop neighbours; many multi-hop detours remain even after several failures.
- Loss of one cable only lowers a single server's degree from 8 to 7; global reachability is unaffected.

0.1.5 Key observations

1. **Vertical choke-points remain.** Extra NICs in the Clos enlarge rack bandwidth but do not remove the dependence on 88 spine-core cables.
2. **Risk distribution.** The mesh spreads failure impact evenly; the Clos still concentrates risk in its upper layers.
3. **Equipment footprint.** The mesh eliminates 30 switches (20 ToRs, 4 spines, 2 cores), trading them for denser lateral cabling.
4. **Graceful degradation.** Clos bisection bandwidth falls in 12.5% or 5% steps; mesh capacity decays proportionally to failed cables, with no cliff.