

Physical structure



[Image: Derrick Coetzee]

VITESSE COLD AISLE CRITERIA
65°F TO 80°F DB
41.9°F TO 59.0°F DP
MAX 65% RH

ASHRAE GUIDELINES
64.4°F TO 80.6°F DB
41.9°F TO 59.0°F DP
MAX 60%RH

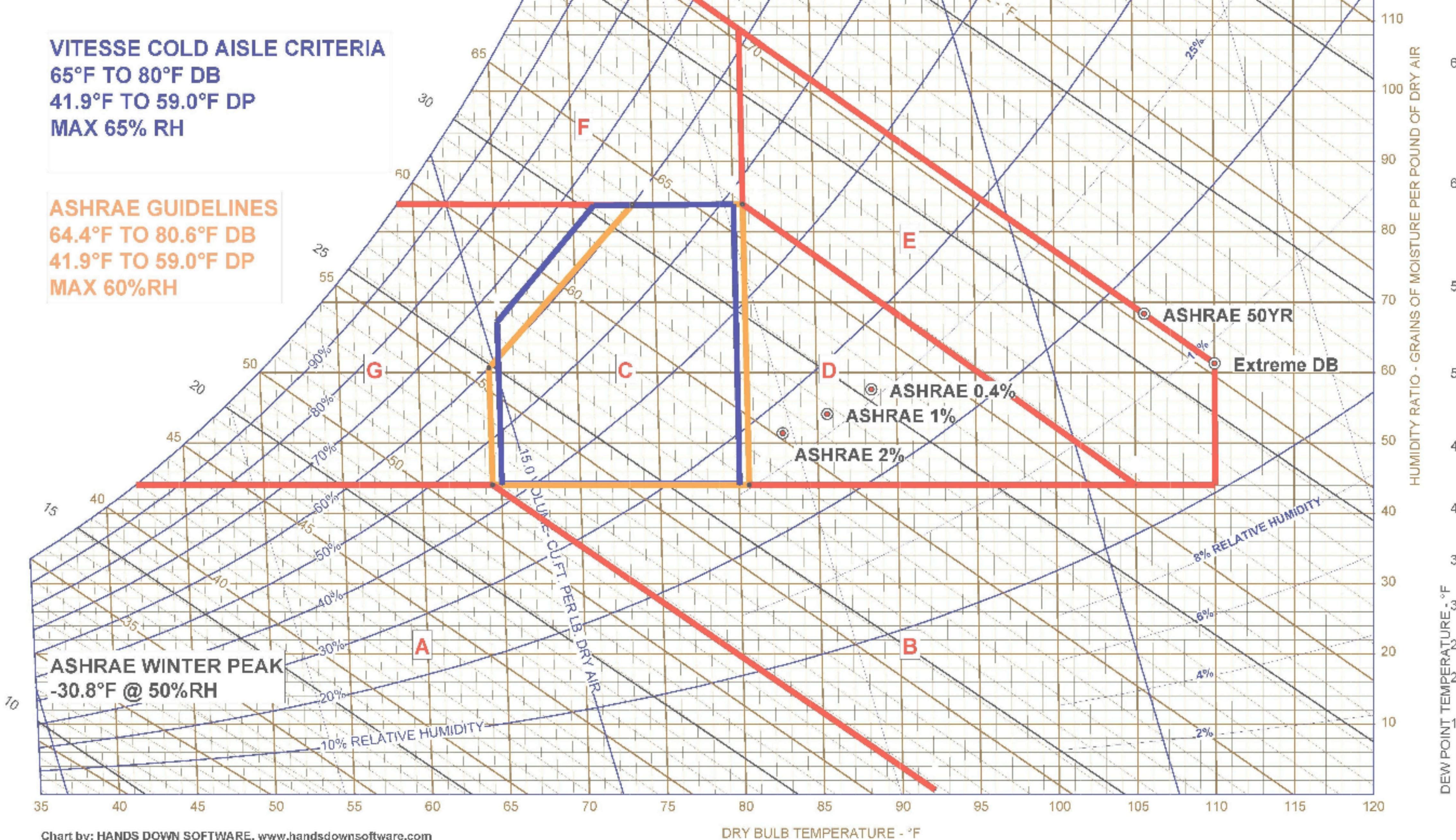


Chart by: HANDS DOWN SOFTWARE, www.handsdownsoftware.com

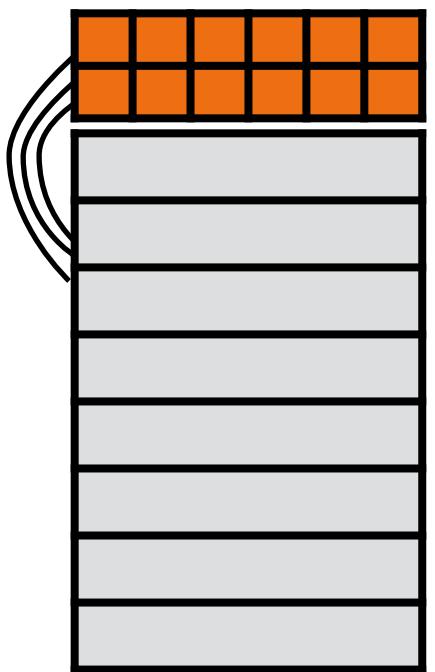
DRY BULB TEMPERATURE - °F

[Data Center v1.0, Open Compute Project]



[Image: Trower, NASA]

A server rack

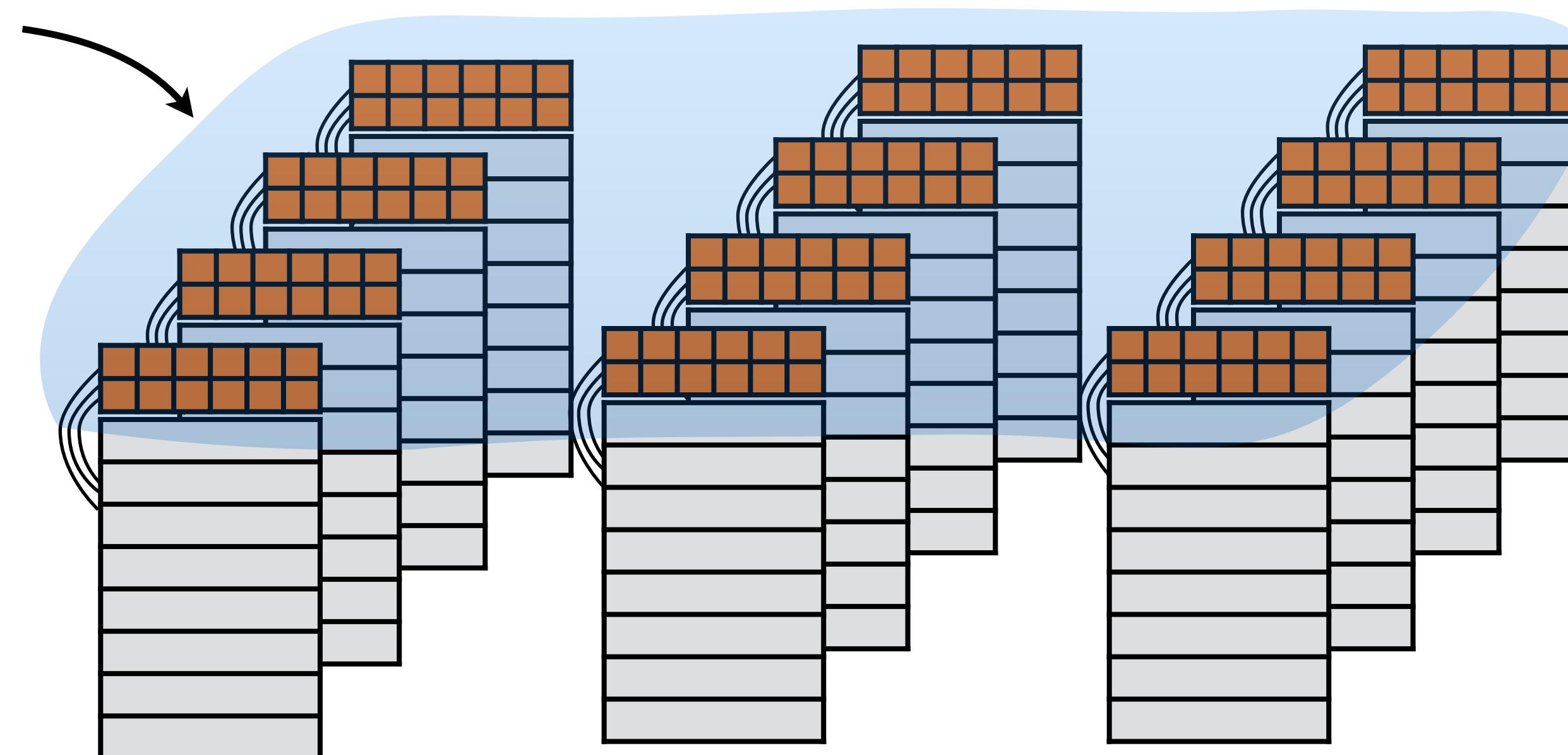


A top-of-rack switch

A rack of servers

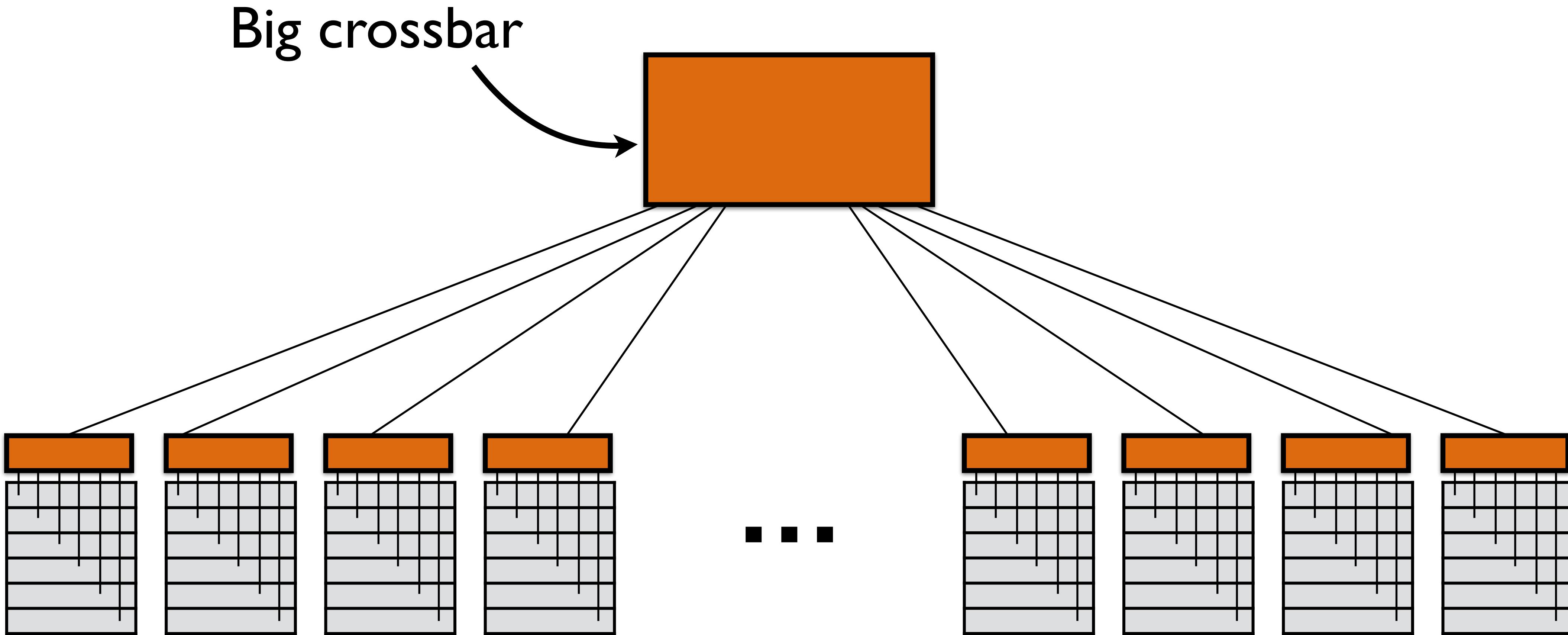
Lots of racks

How to network
the racks?

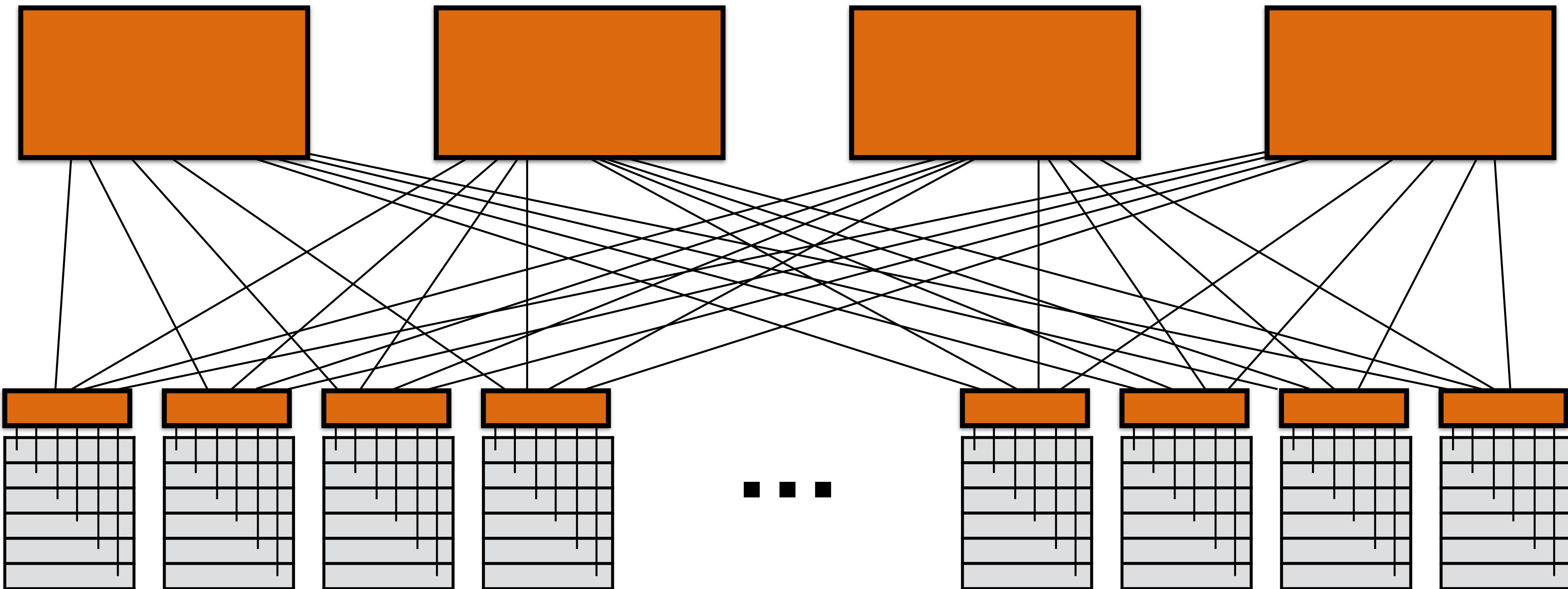


Facebook: machine-machine traffic “doubling at an interval of less than a year”

“Big switch” approach

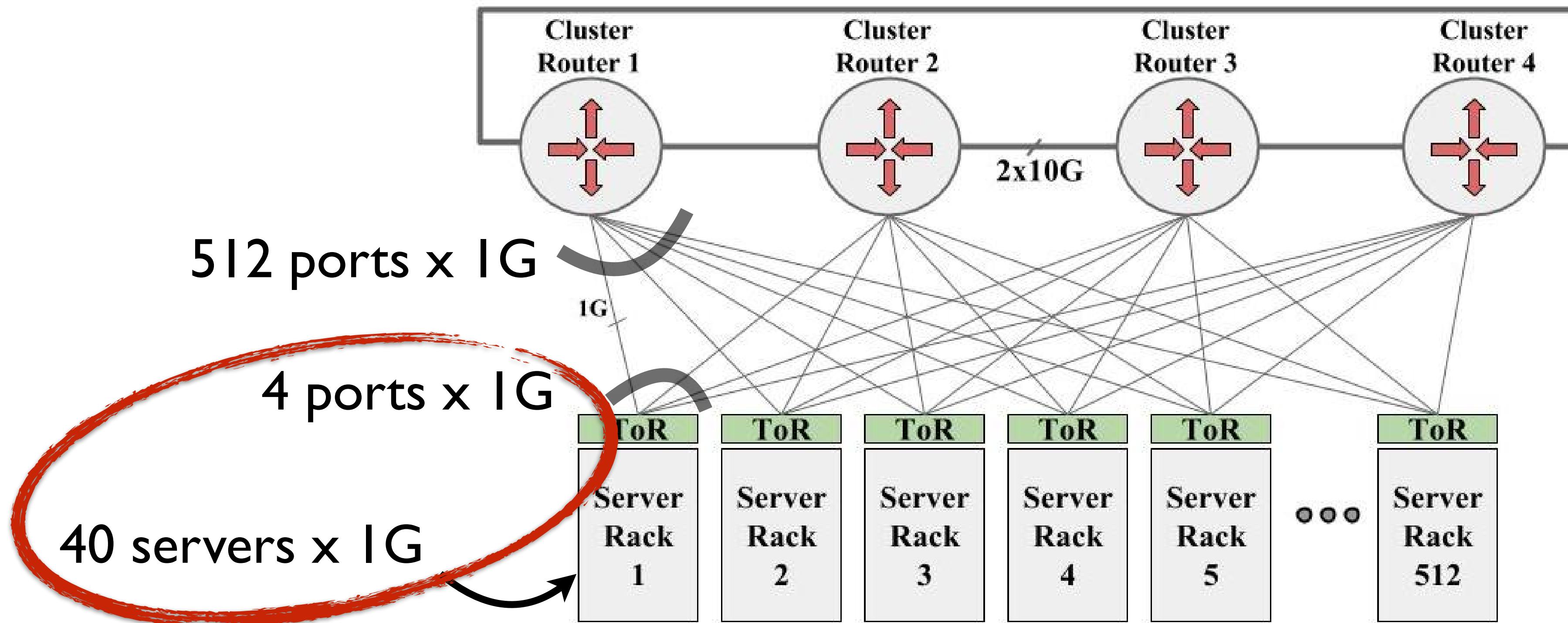


“Big switch” approach

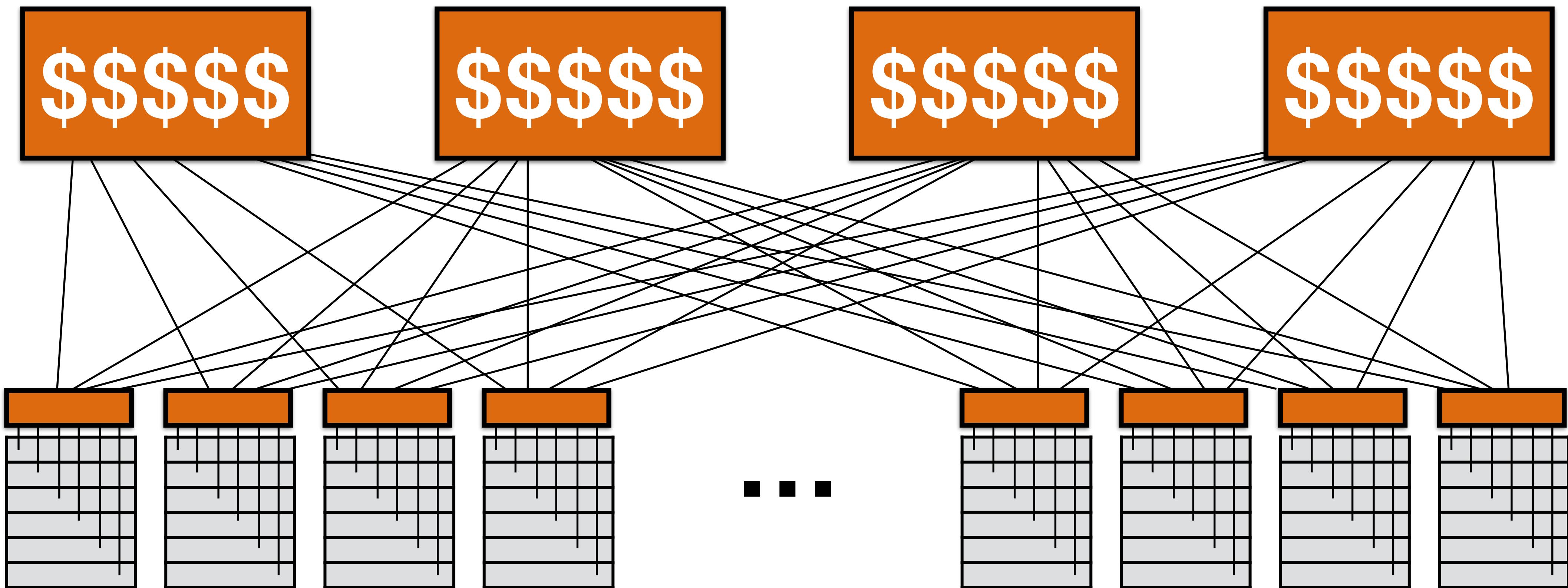


Jupiter Rising: A Decade of Clos Topologies and Centralized Control in Google's Datacenter Network

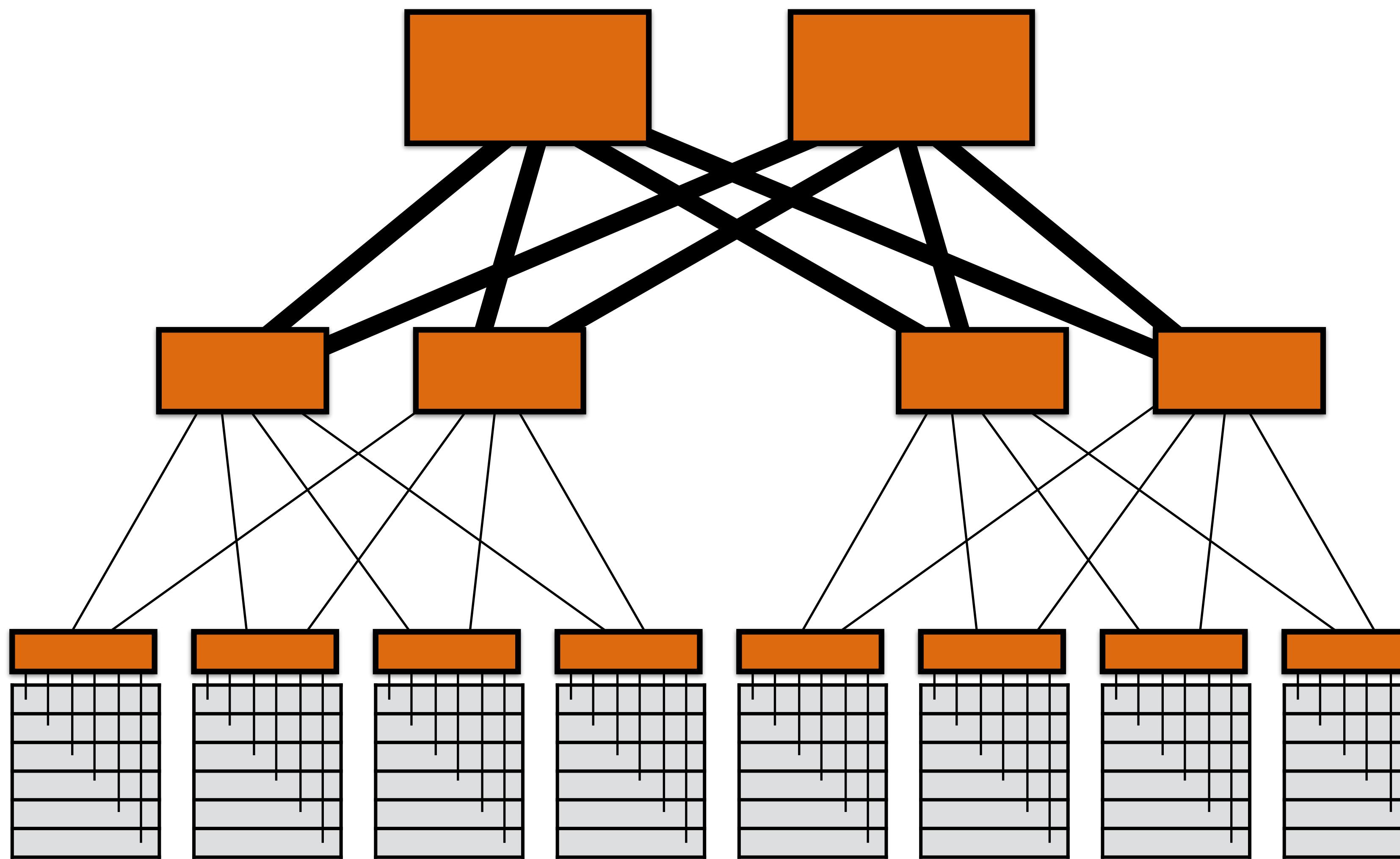
Arjun Singh, Joon Ong, Amit Agarwal, Glen Anderson, Ashby Armistead, Roy Bannon, Seb Boving, Gaurav Desai, Bob Felderman, Paulie Germano, Anand Kanagala, Jeff Provost, Jason Simmons, Eiichi Tanda, Jim Wanderer, Urs Hözle, Stephen Stuart, and Amin Vahdat
Google, Inc.



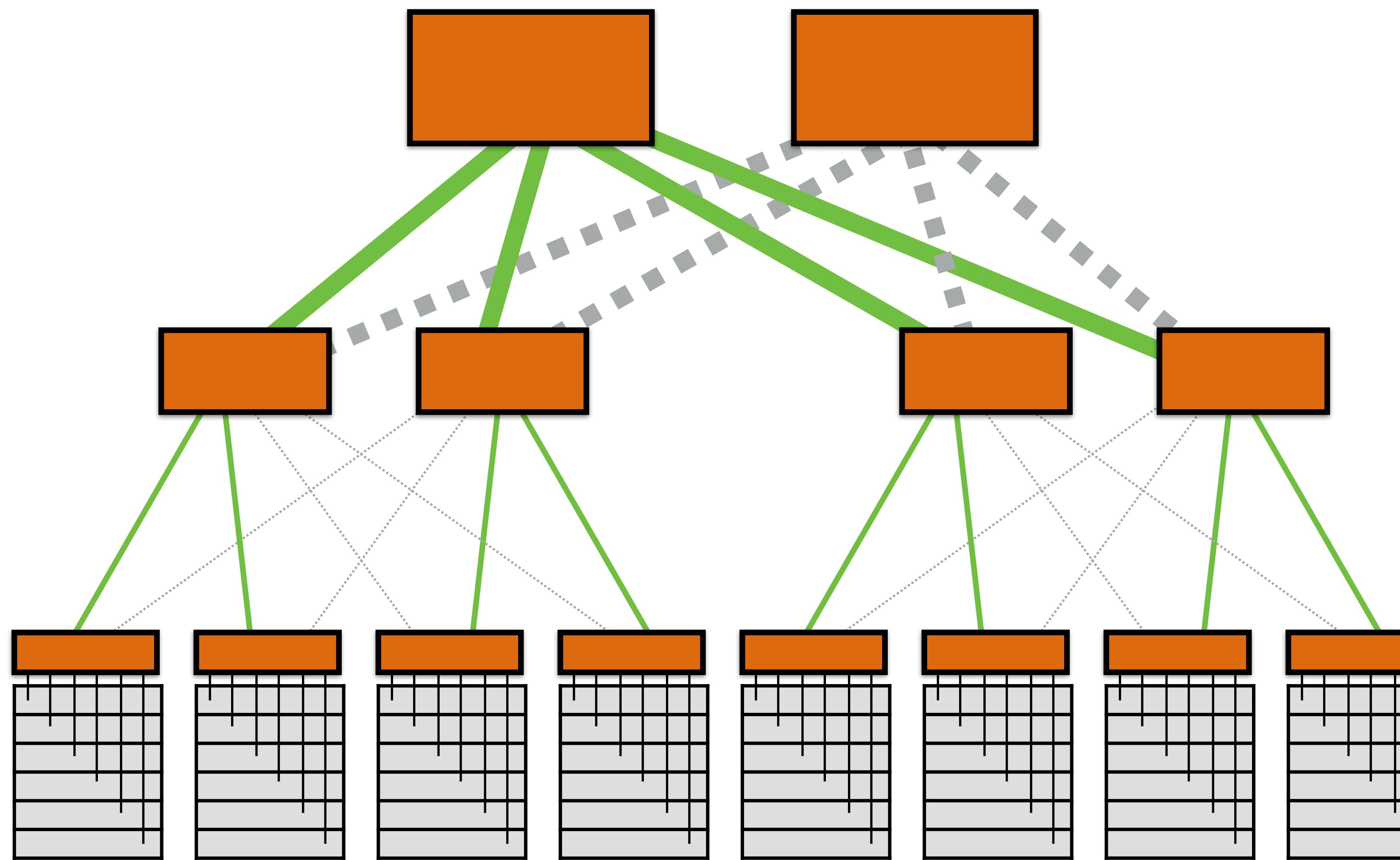
“Big switch” approach



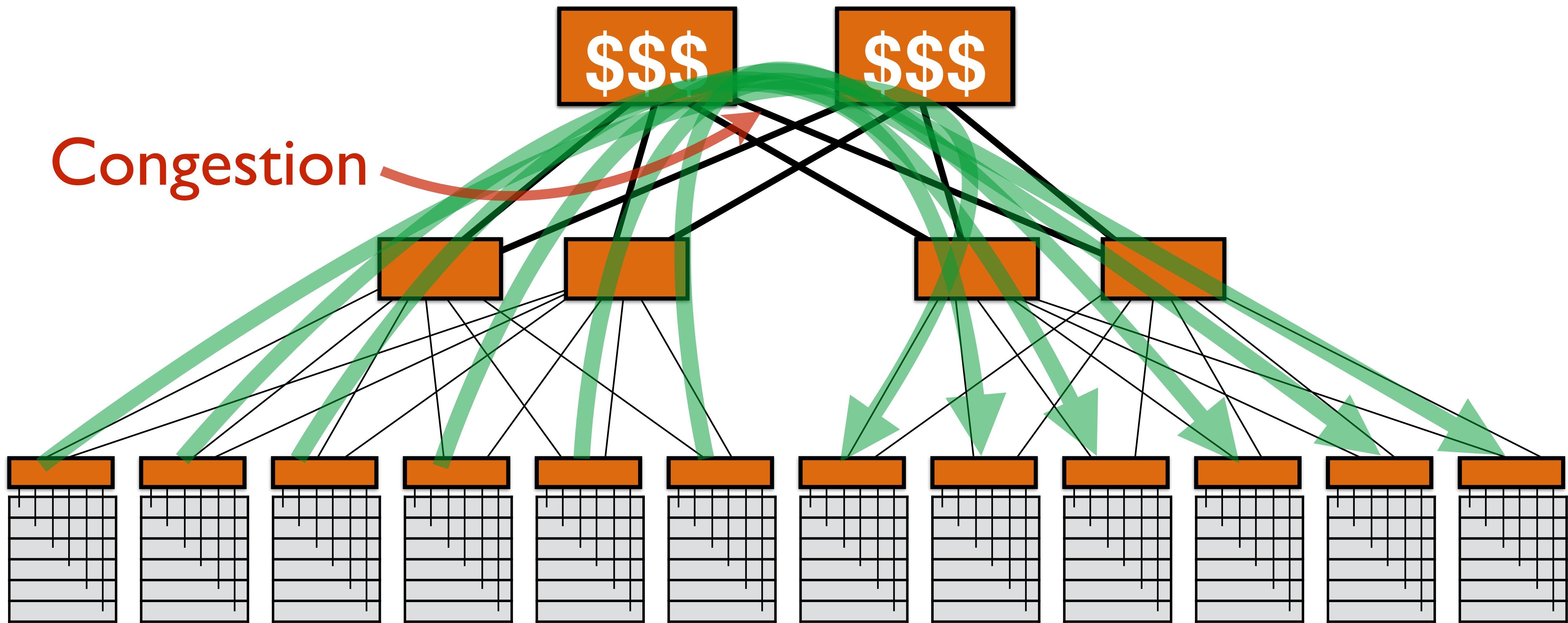
Alternative: tree network



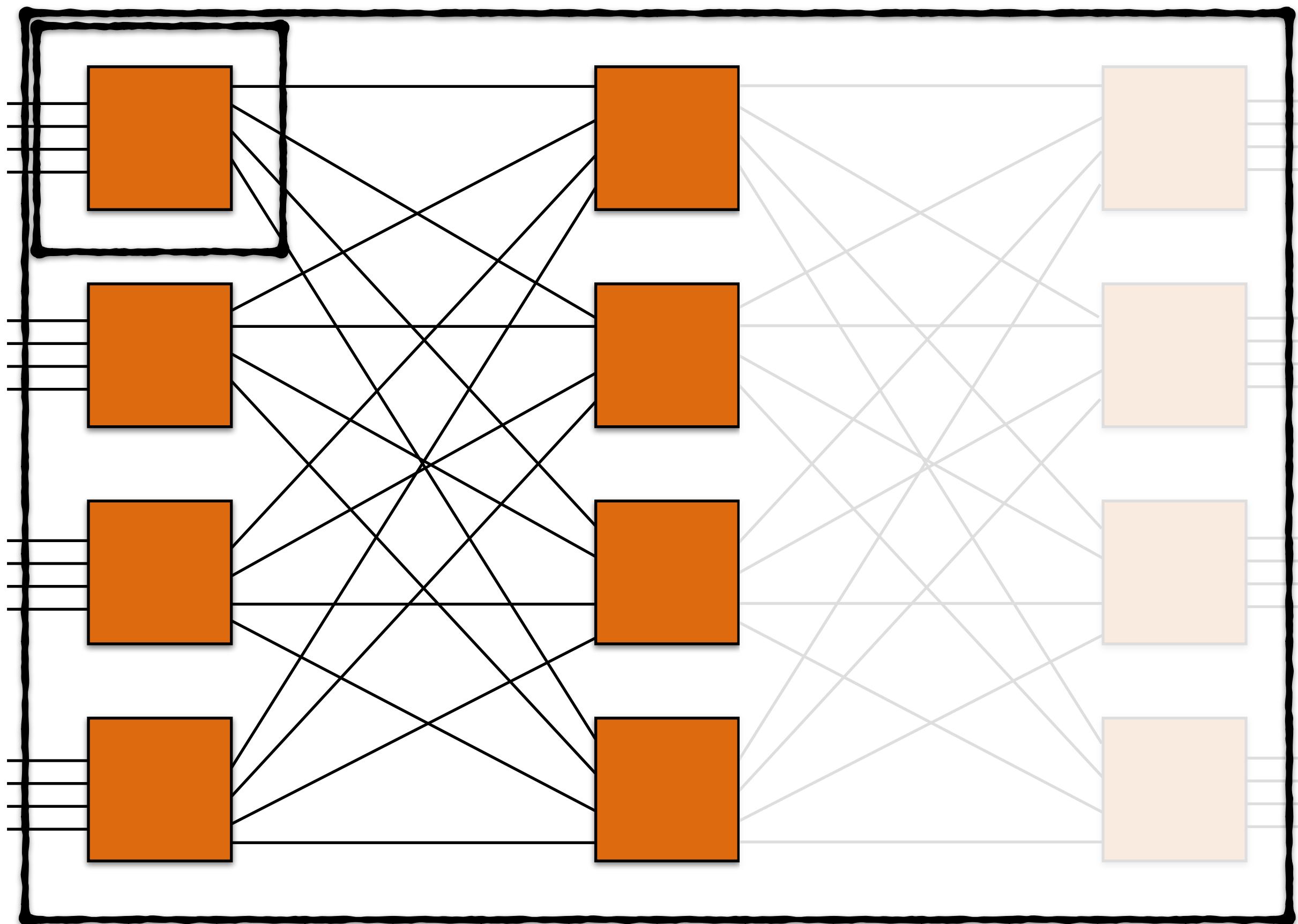
Alternative: tree network



Alternative: tree network

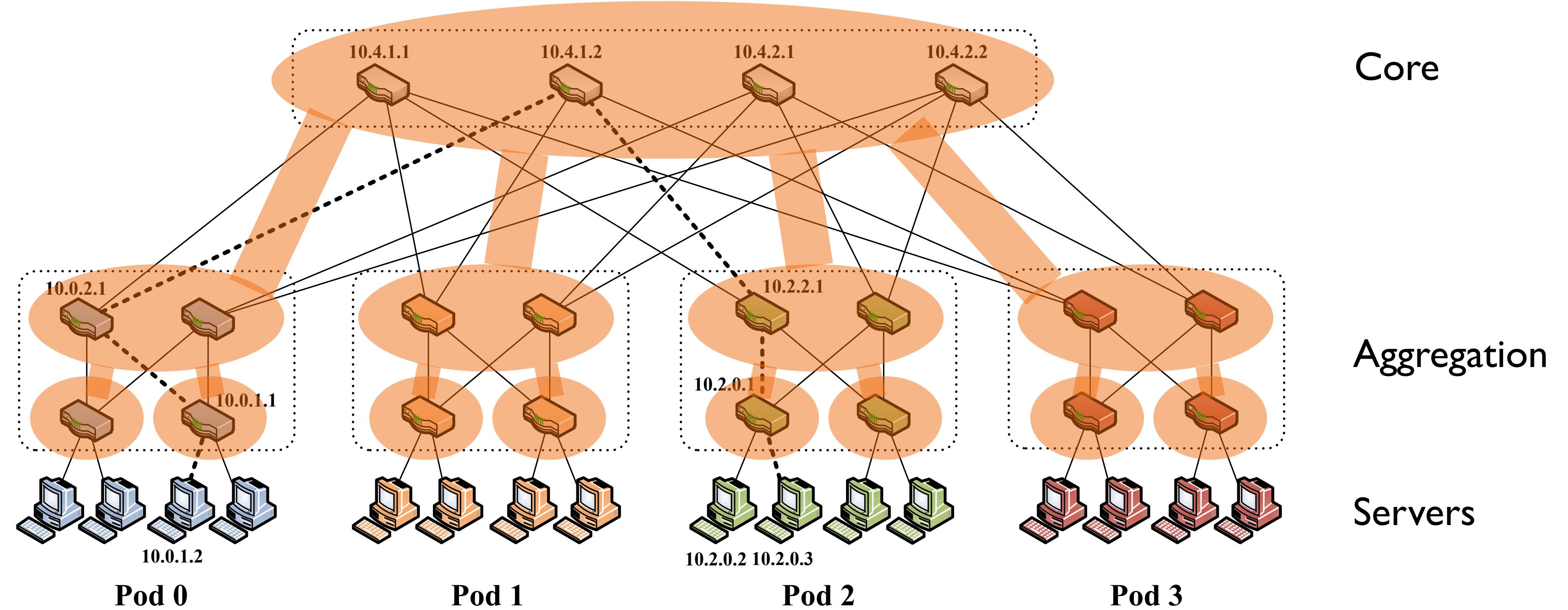


Clos networks to the rescue



Use small, cheap elements to build large capacity-rich networks

Fat-tree network



ACM SIGCOMM, 2008

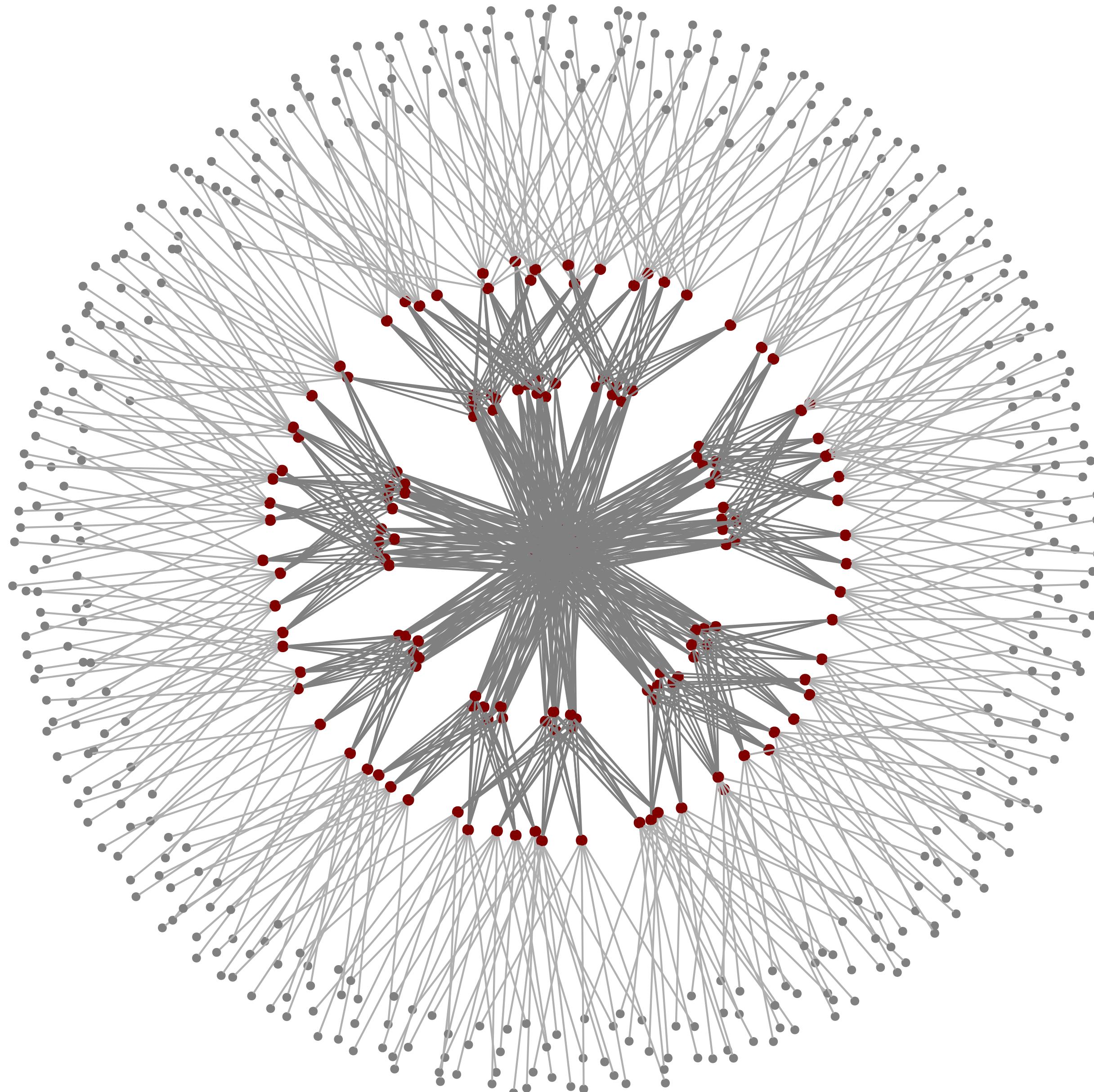
A Scalable, Commodity Data Center Network Architecture

Mohammad Al-Fares

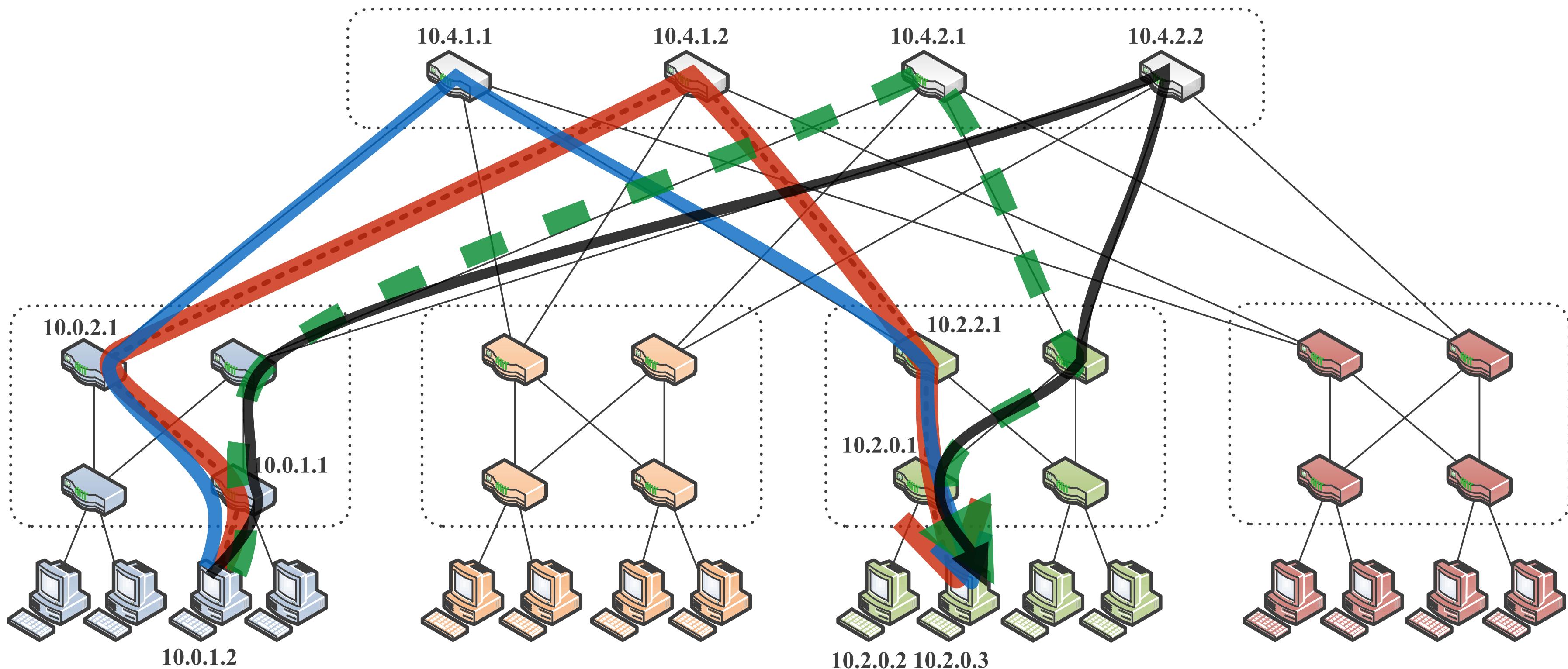
Alexander Loukissas

Amin Vahdat

Fat-tree network



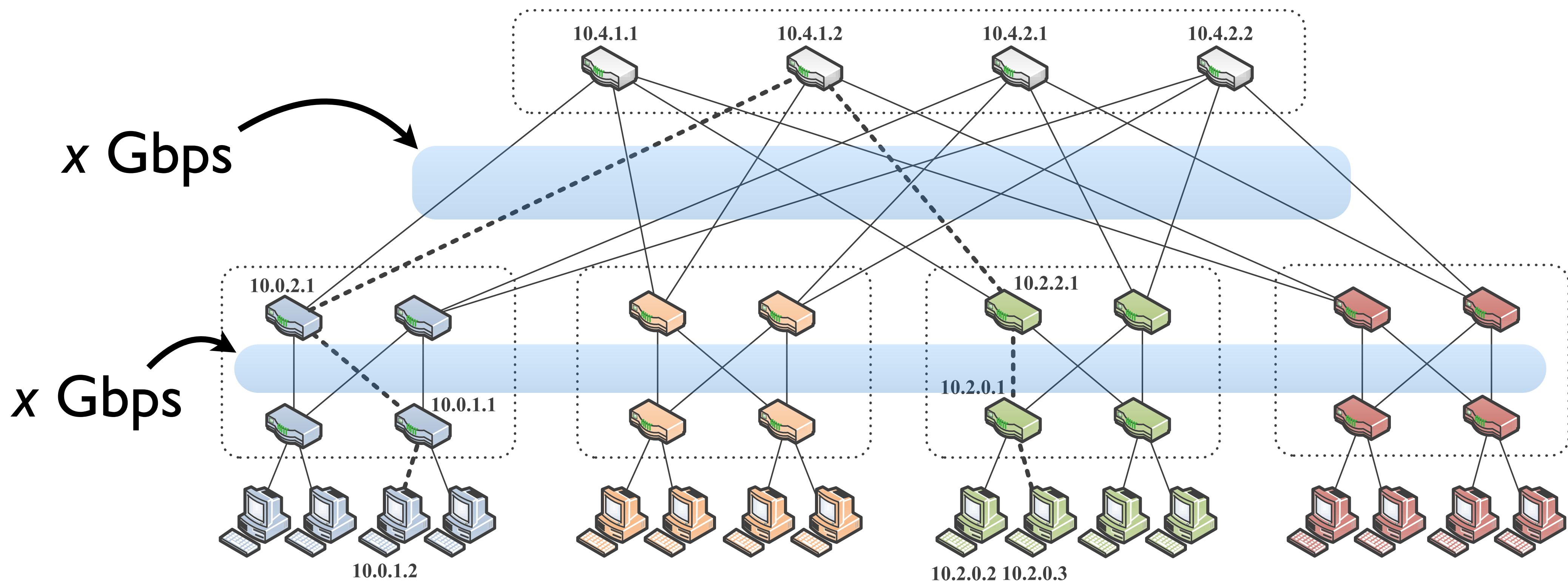
Fat-tree network



ACM SIGCOMM, 2008

A Scalable, Commodity Data Center Network Architecture

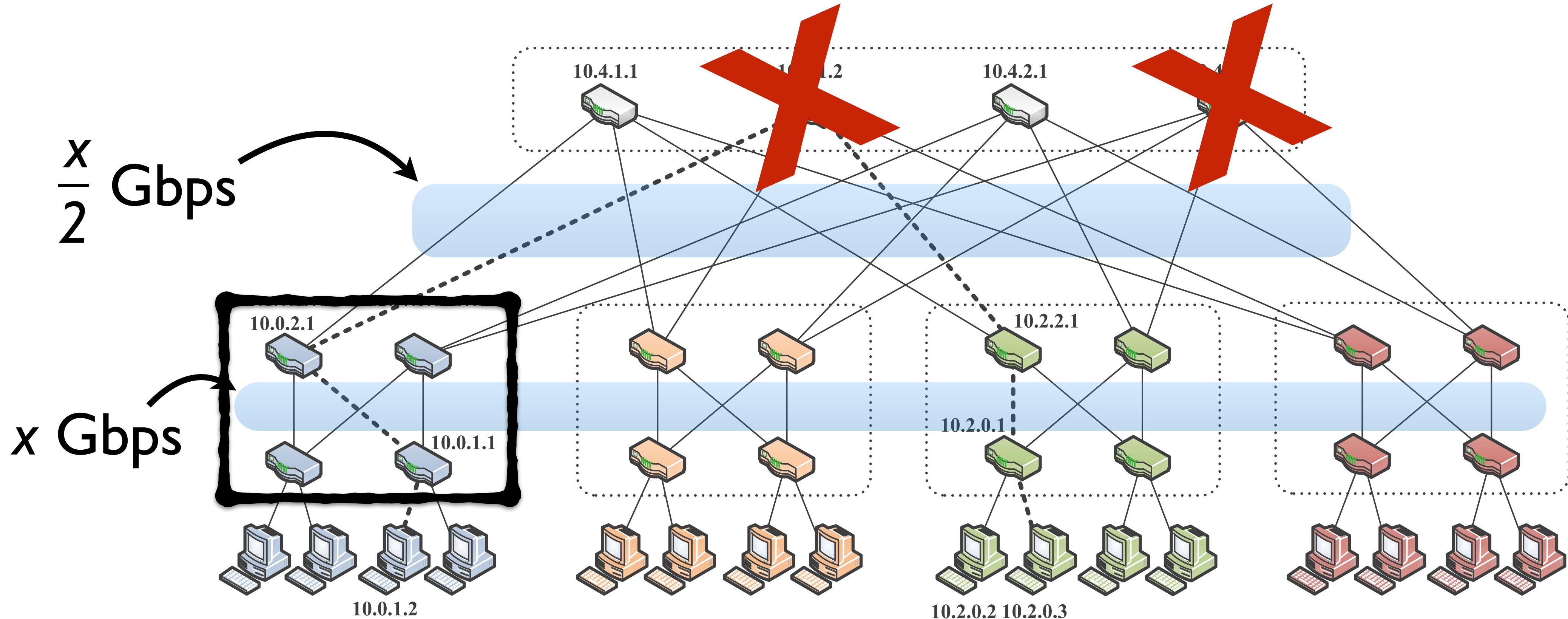
Fat-tree network



ACM SIGCOMM, 2008

A Scalable, Commodity Data Center Network Architecture

Fat-tree network

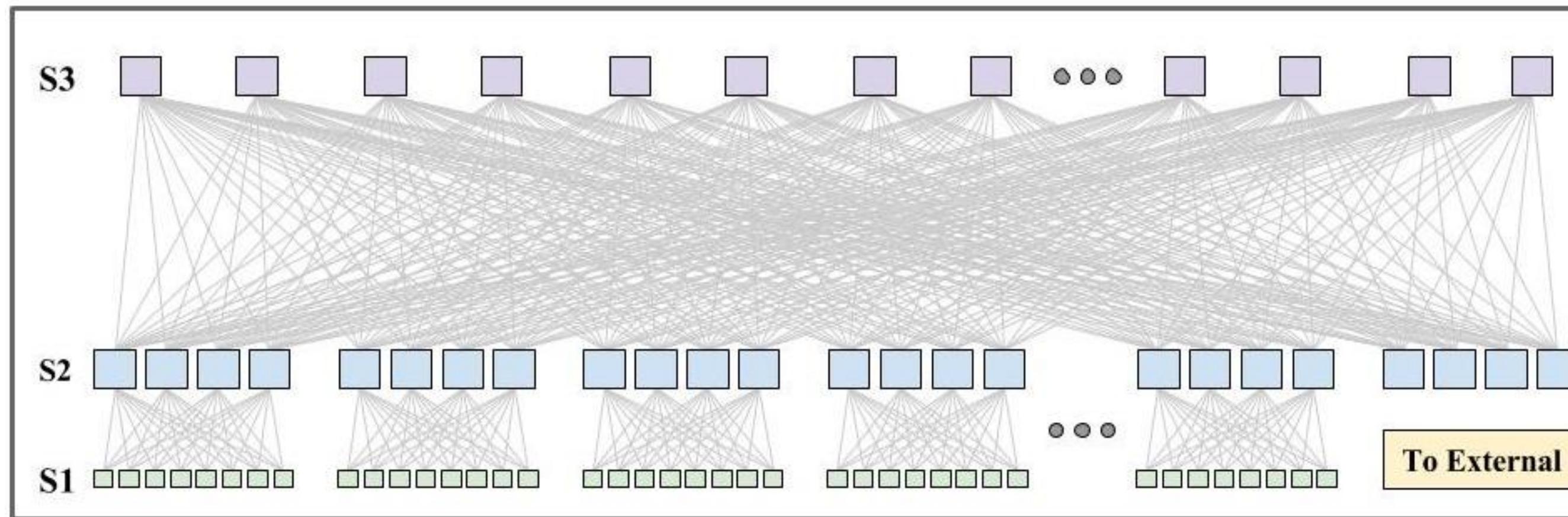


ACM SIGCOMM, 2008

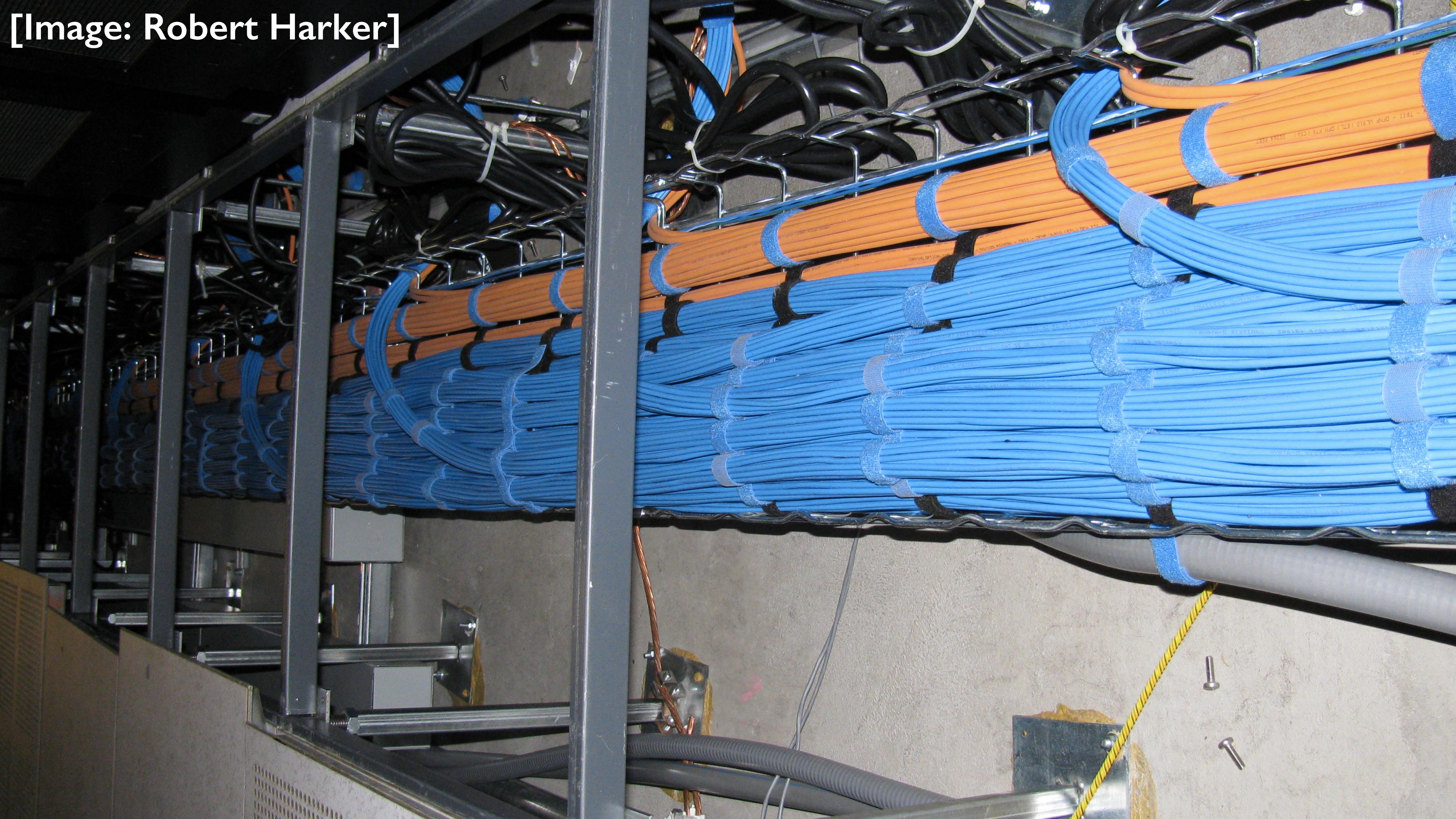
A Scalable, Commodity Data Center Network Architecture

Jupiter Rising: A Decade of Clos Topologies and Centralized Control in Google's Datacenter Network

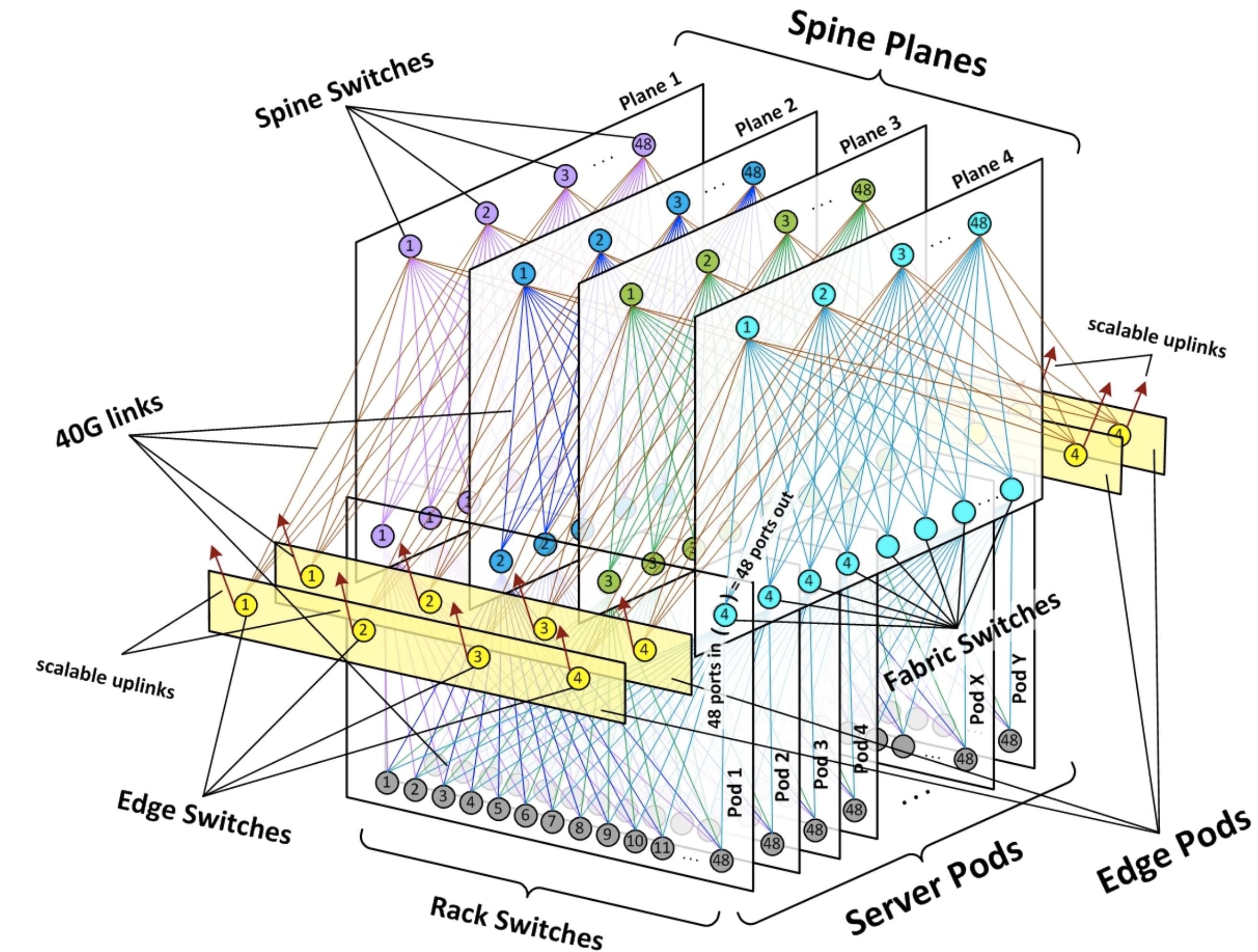
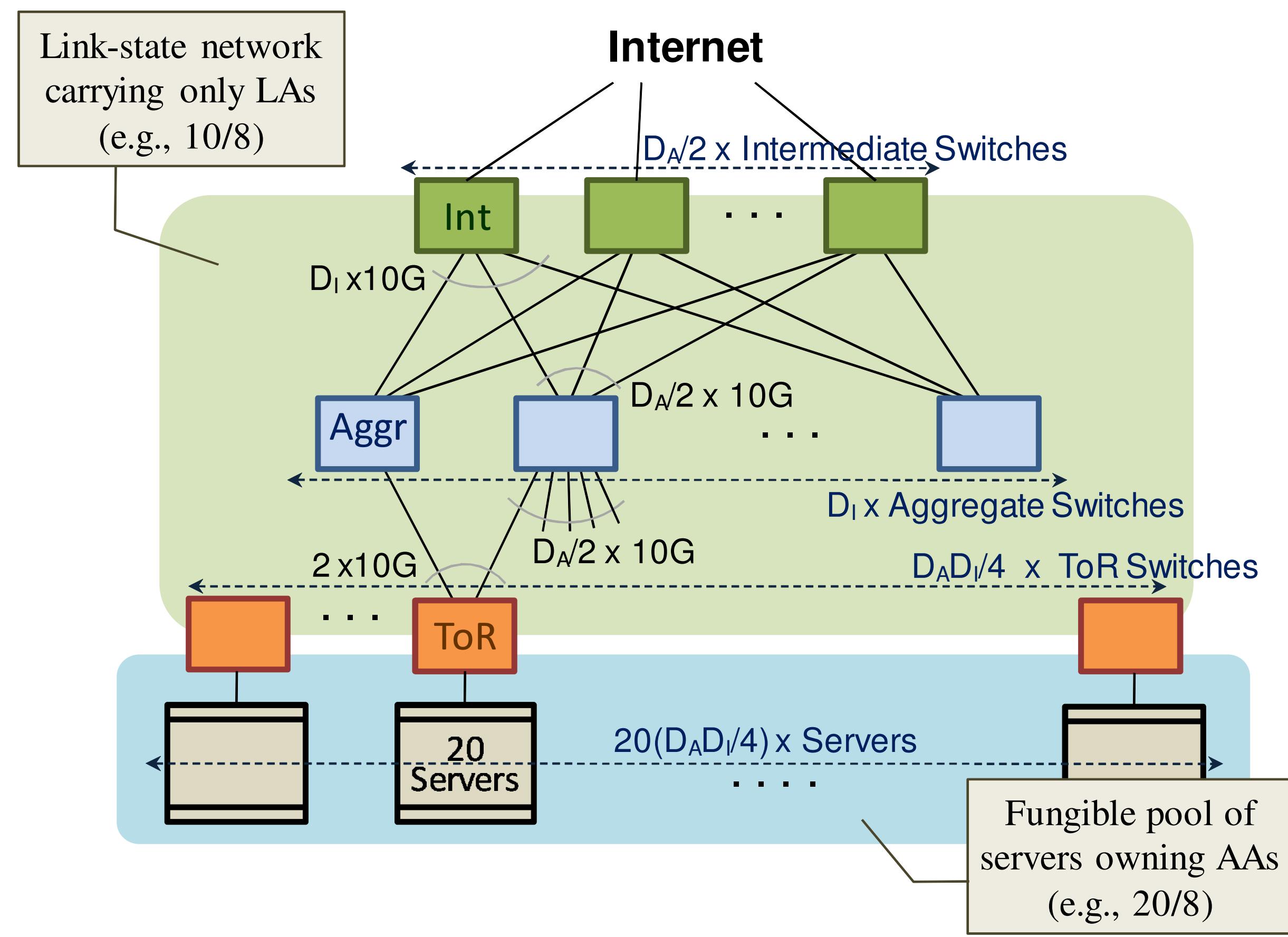
Arjun Singh, Joon Ong, Amit Agarwal, Glen Anderson, Ashby Armistead, Roy Bannon,
Seb Boving, Gaurav Desai, Bob Felderman, Paulie Germano, Anand Kanagala, Jeff Provost,
Jason Simmons, Eiichi Tanda, Jim Wanderer, Urs Hözle, Stephen Stuart, and Amin Vahdat
Google, Inc.



[Image: Robert Harker]



Variants of this design are common



There are other design possibilities too

