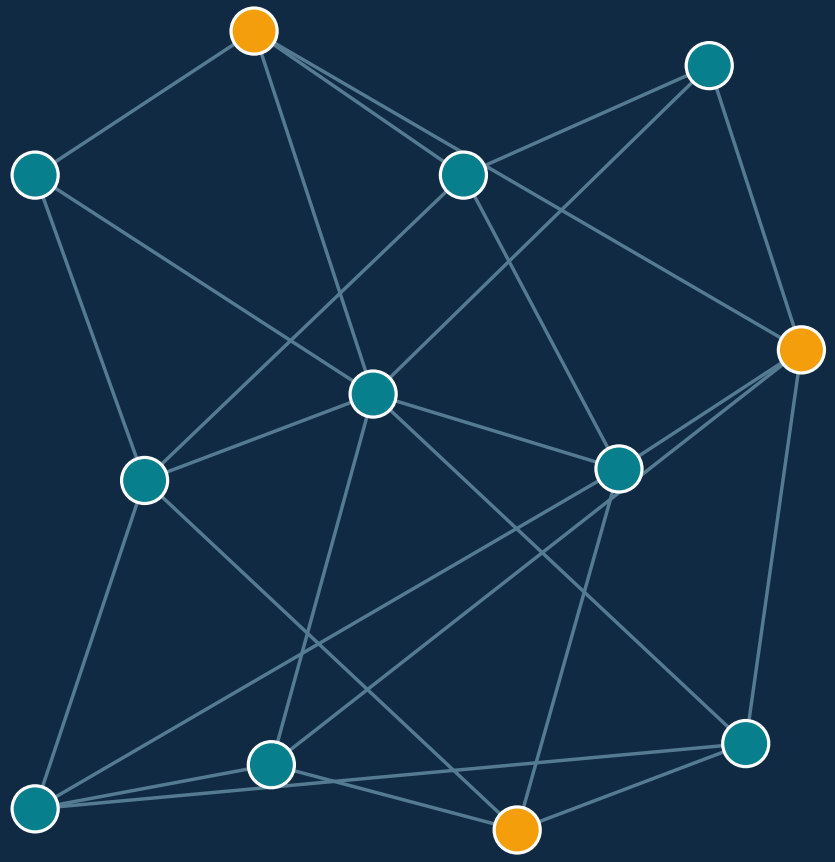
NANOG 98 | Oct 2026

RNG: Flat datacenter networks at scale



Ratul Mahajan w/ Giacomo Bernardi, C. Seshadhri, and many others
Amazon

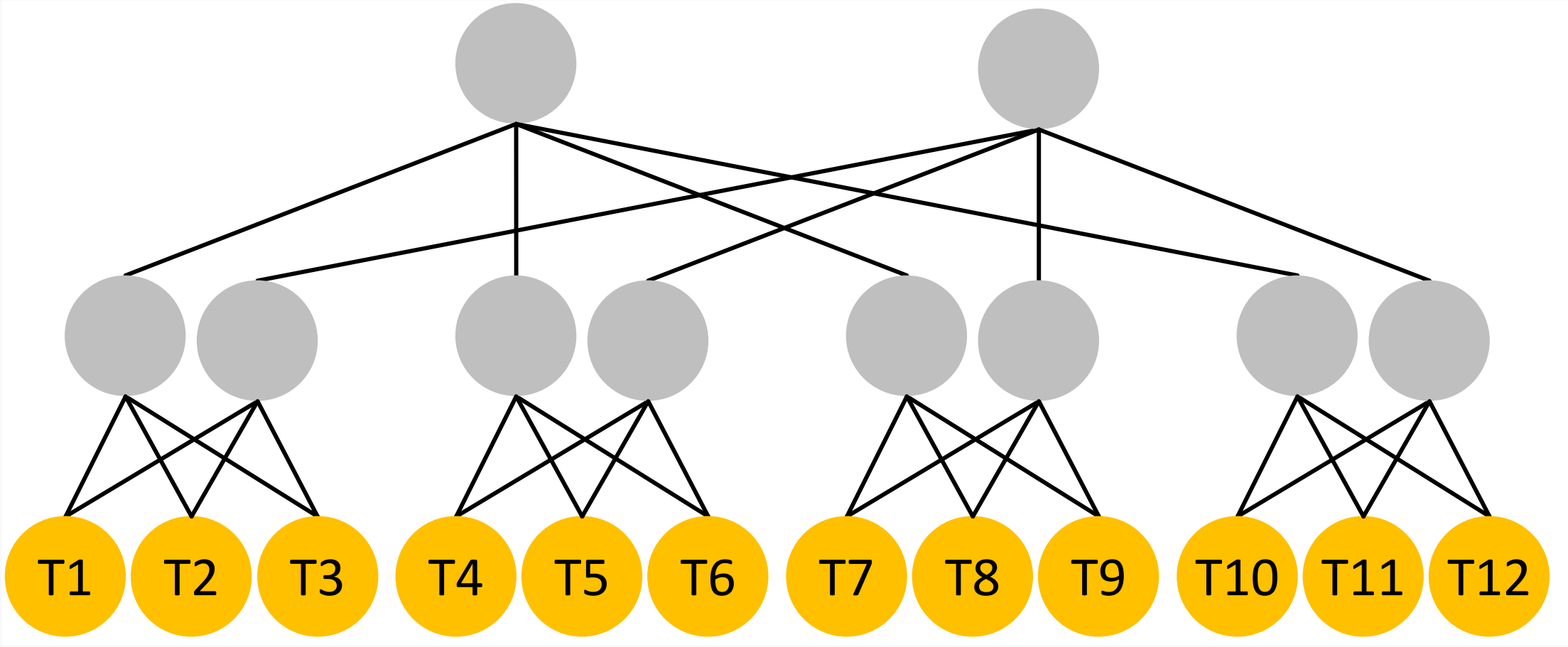
RNG flattens the datacenter network

69%
fewer switches

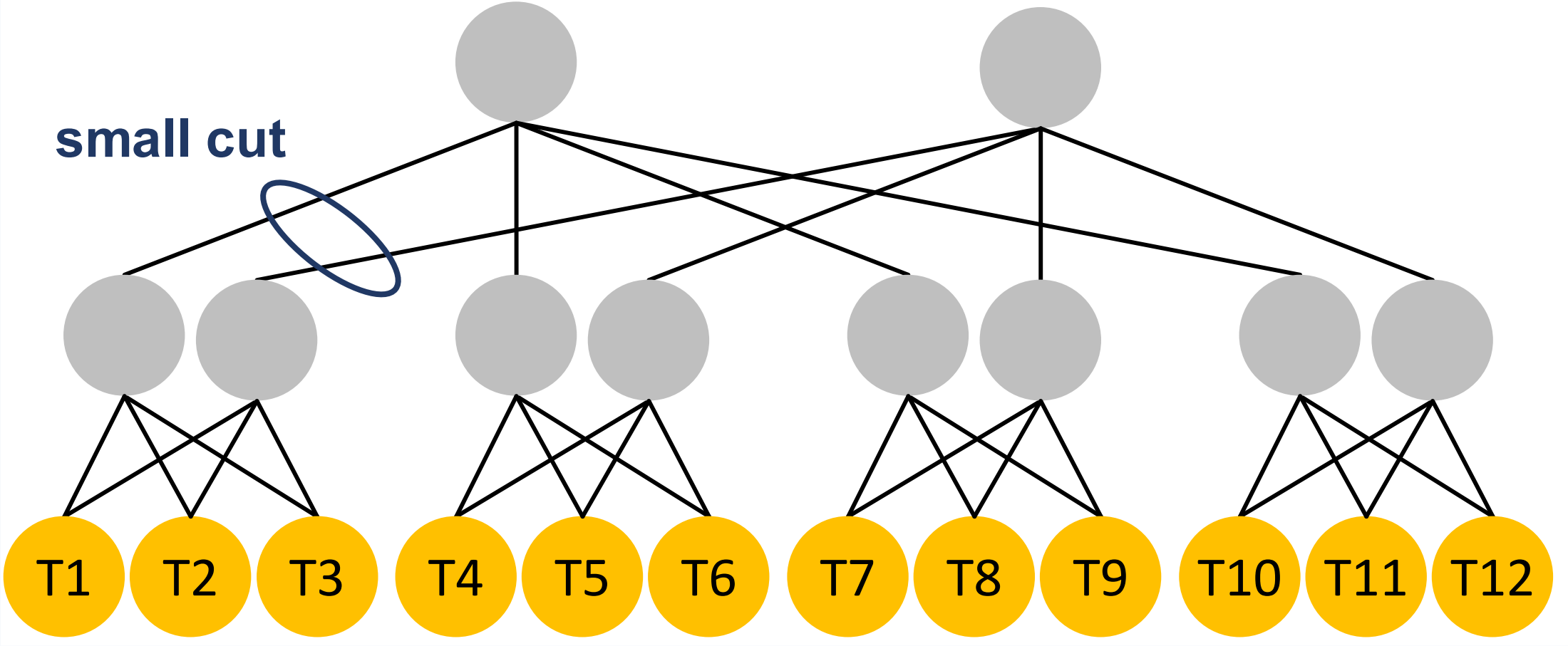
40%
less power

27%
lower cost

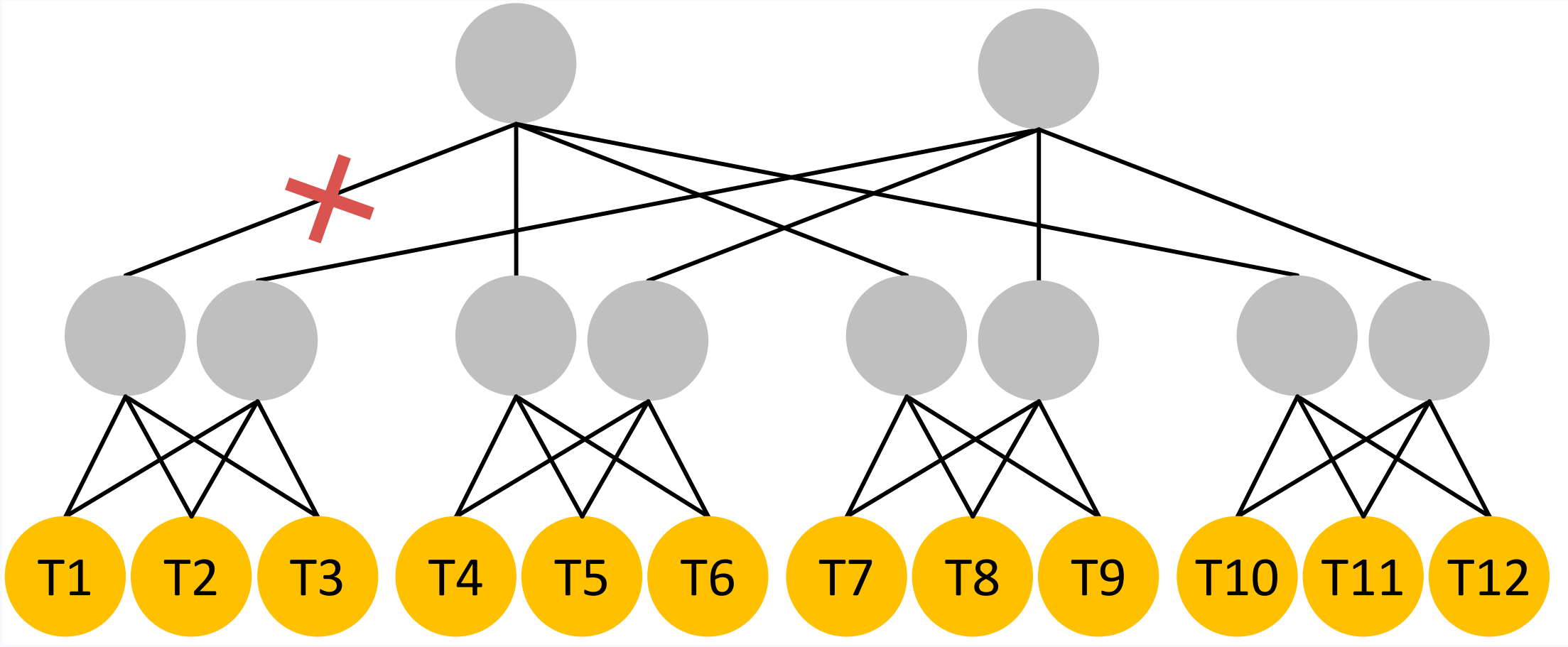
Trees are simple to cable, route, and analyze



But trees strand capacity



Failures have outsized impact in trees

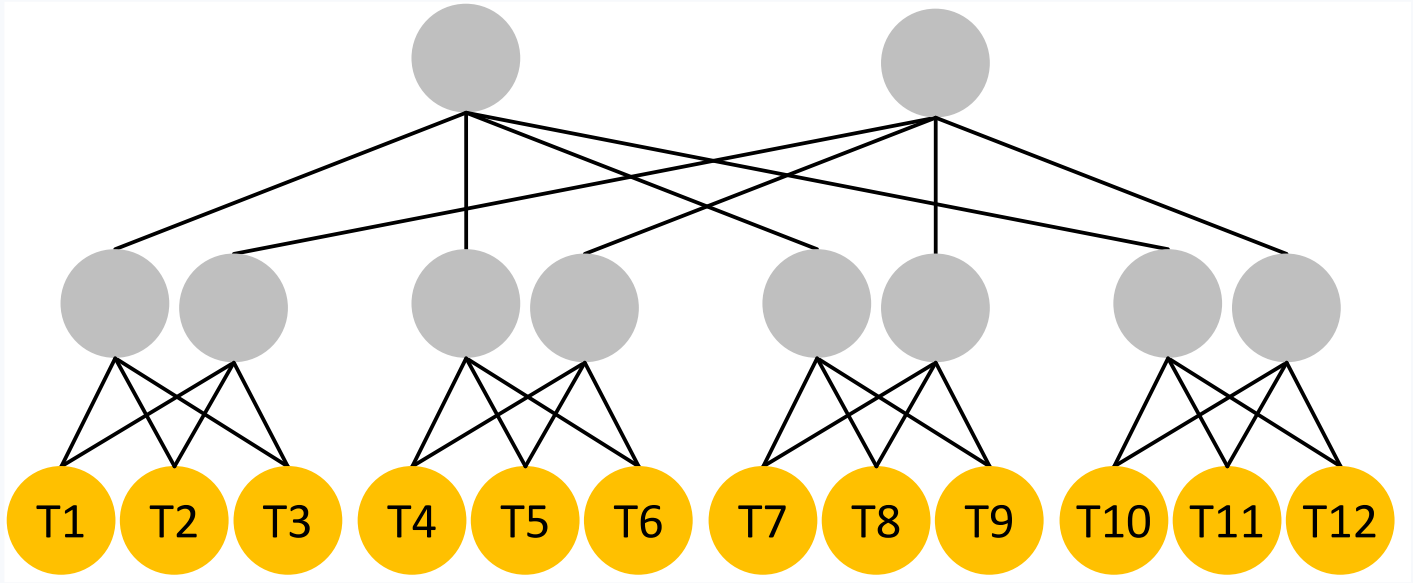


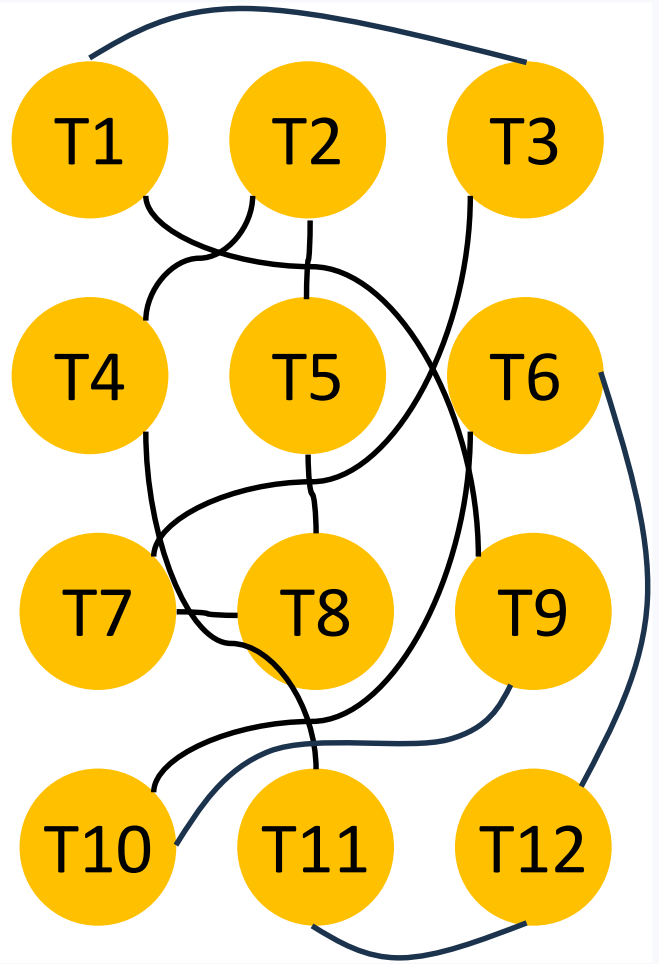
Mitigating the downsides of trees is not easy

$ **Overbuild**

↻ **Reconfigure**

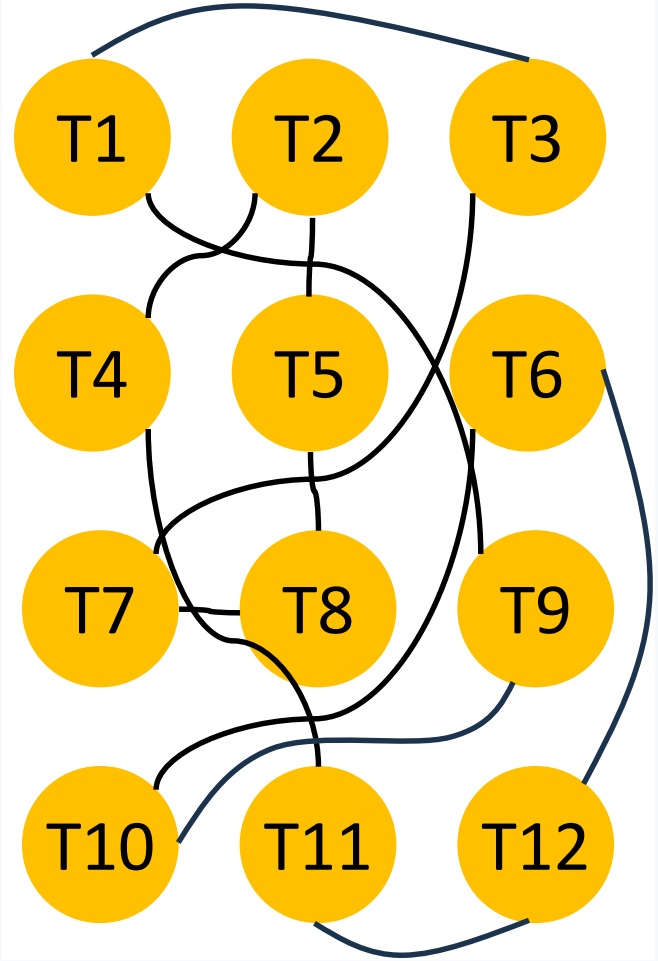
Expander graphs make capacity fungible





But expanders are not easy to build

1. Cabling
2. Routing
3. Predictability



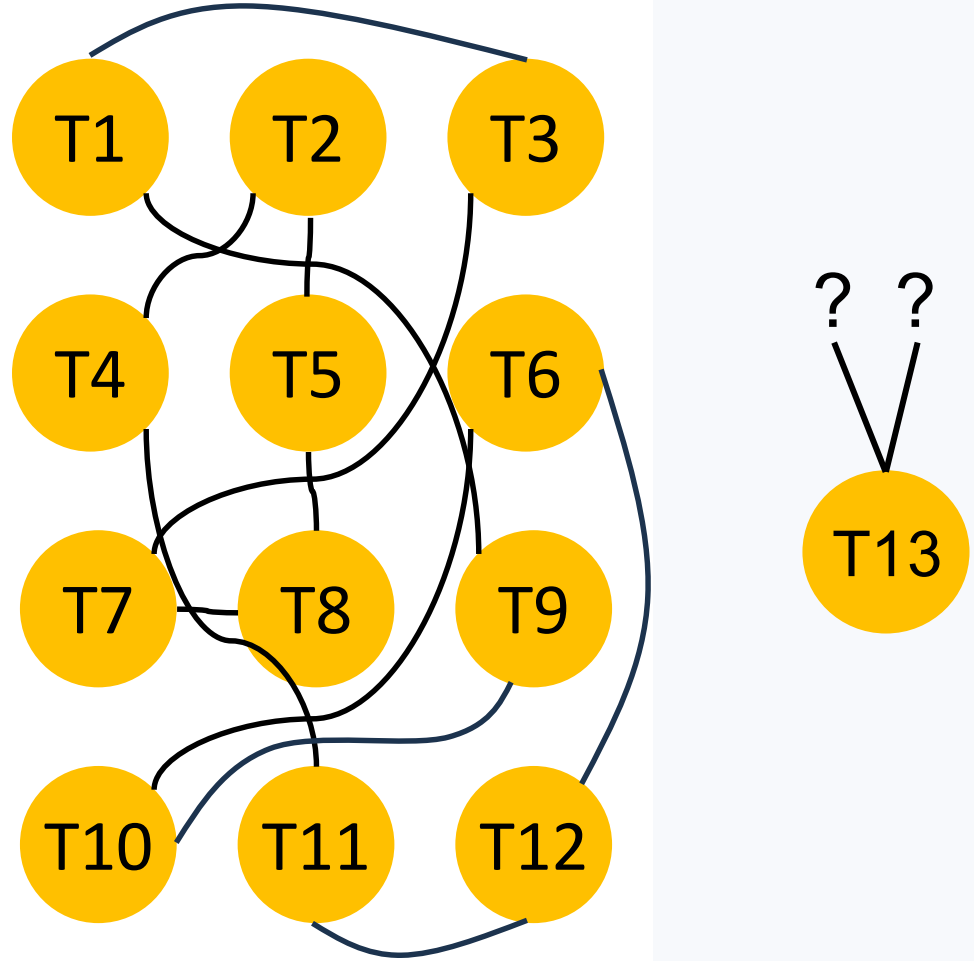
RNG: ~~Random~~ Resilient network graphs

1. Cabling — SHUFFLEBOX
2. Routing — SPRAYPOINT
3. Predictability — MODELS

Cabling: Physical world resists randomness

Arbitrary neighbors

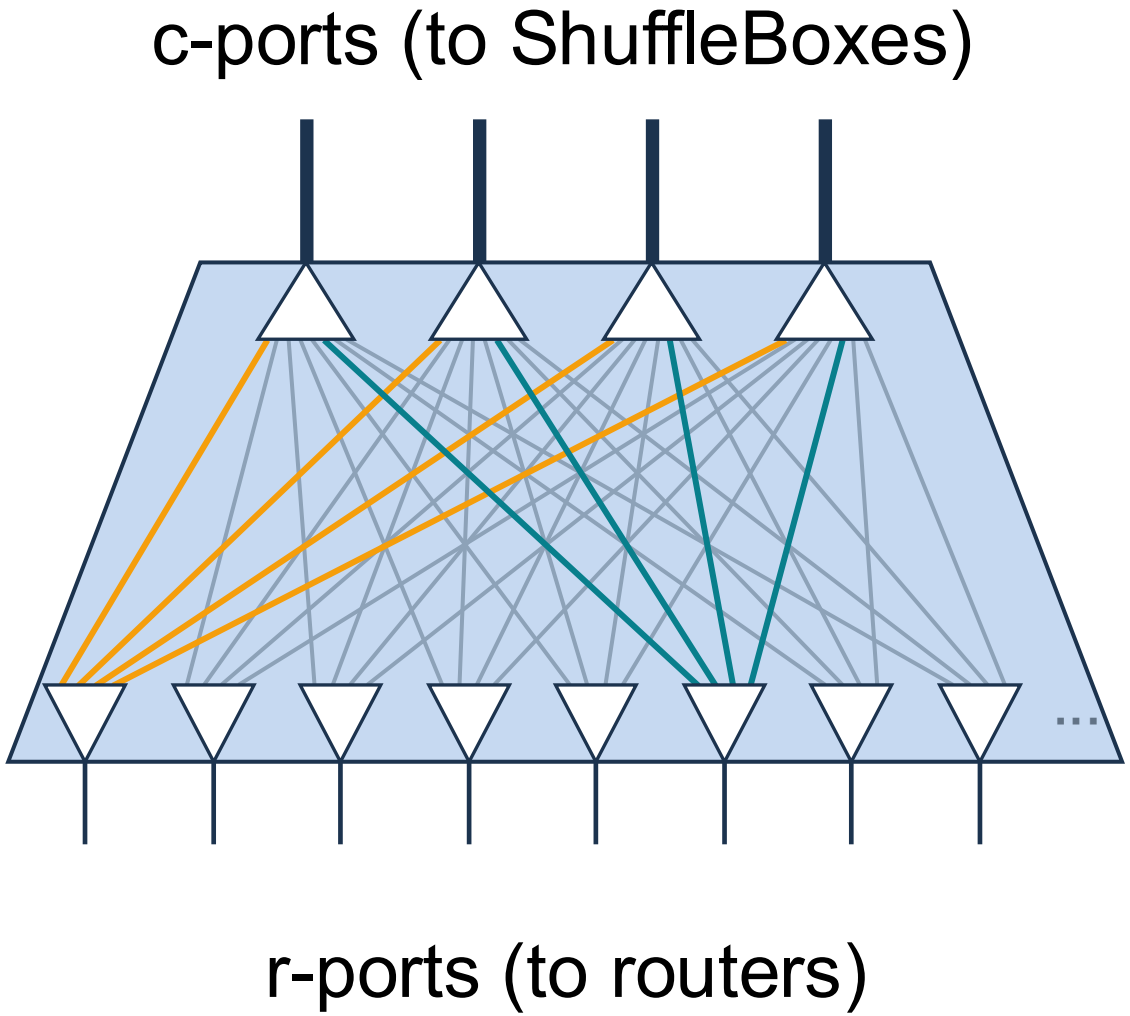
Integrating new routers



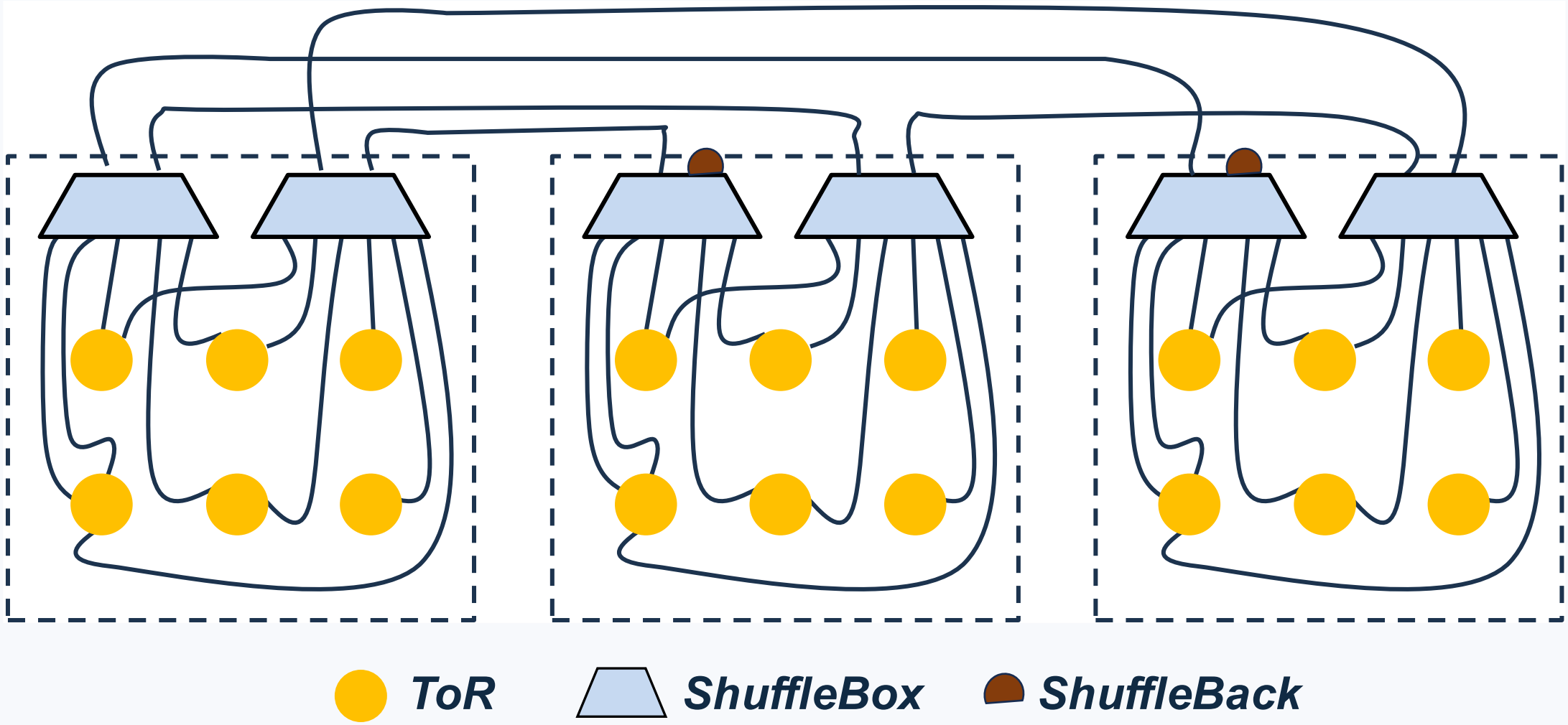
ShuffleBox: A passive optical device



ShuffleBox: A passive optical device



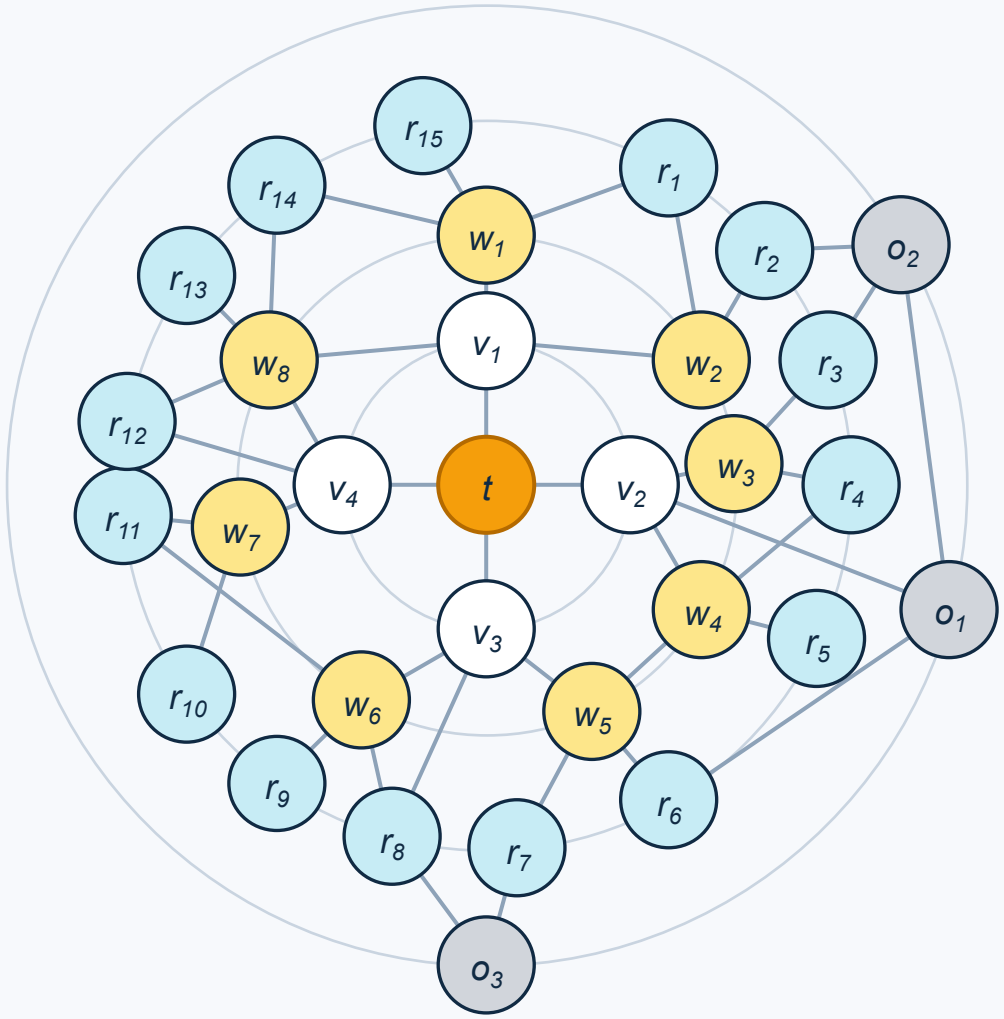
Quasi-random connectivity via structured cabling



Routing: Shortest paths limit throughput

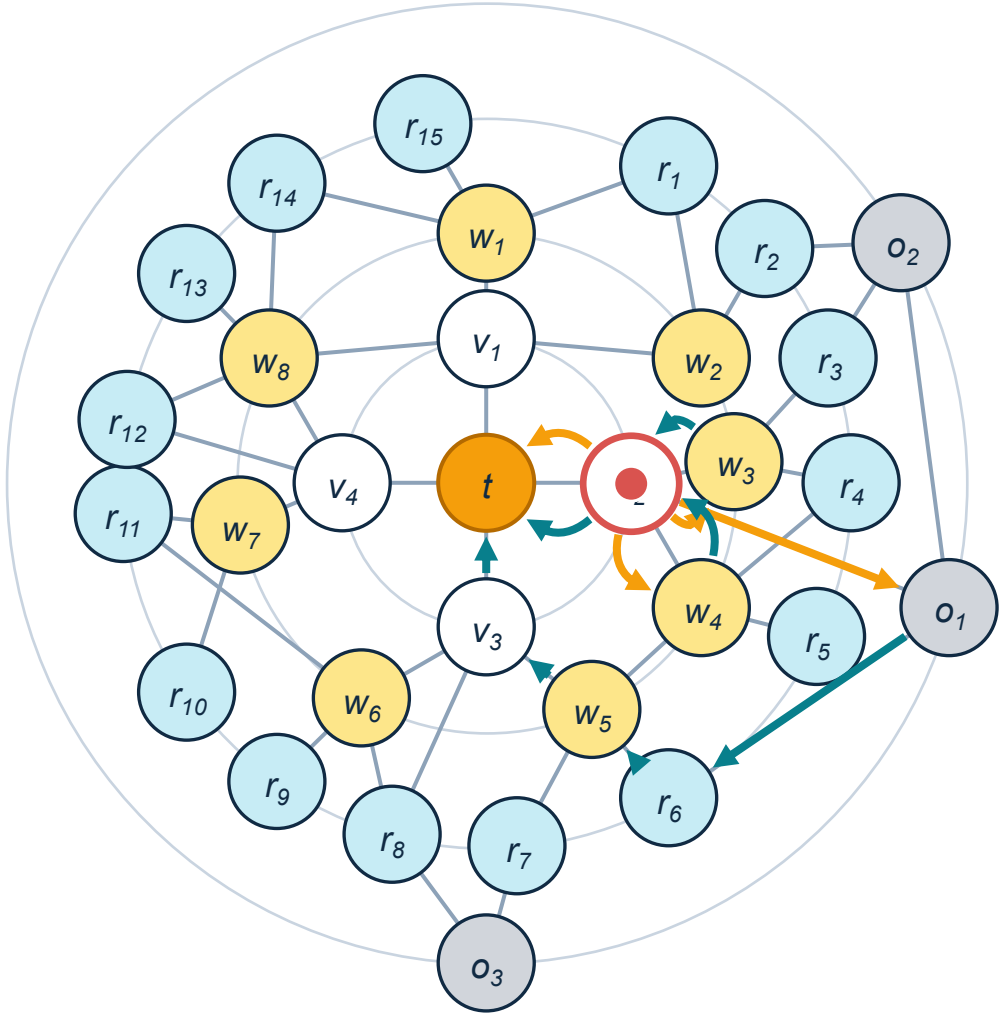


Spraypoint routing



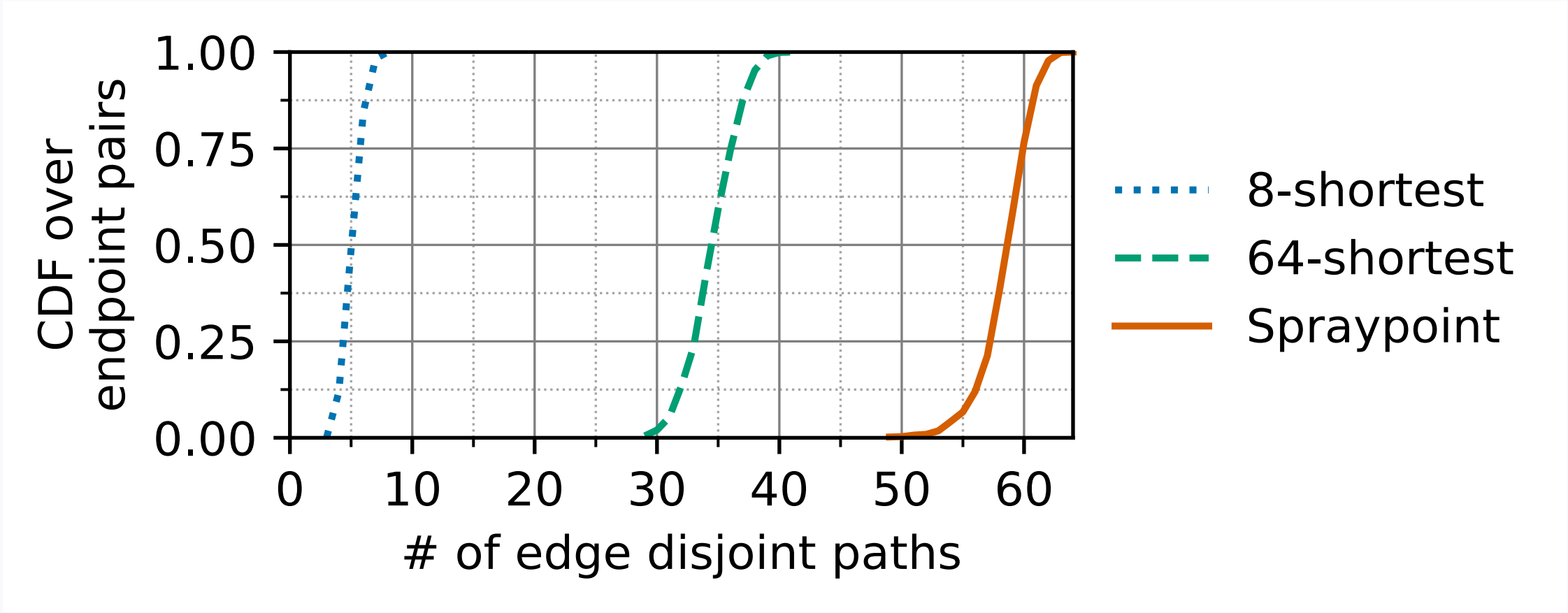
- ***Waypoints at level 0***
- ***Waypoints at level 1***
- ***Inner ring***
- ***Outer ring***

Spraypoint routing

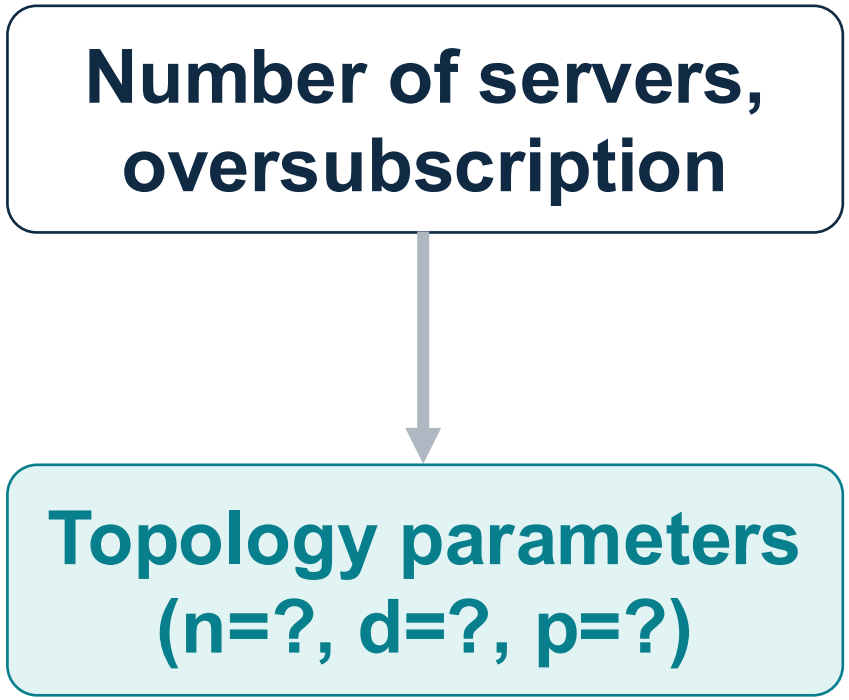


- ***Waypoints at level 0***
- ***Waypoints at level 1***
- ***Inner ring***
- ***Outer ring***

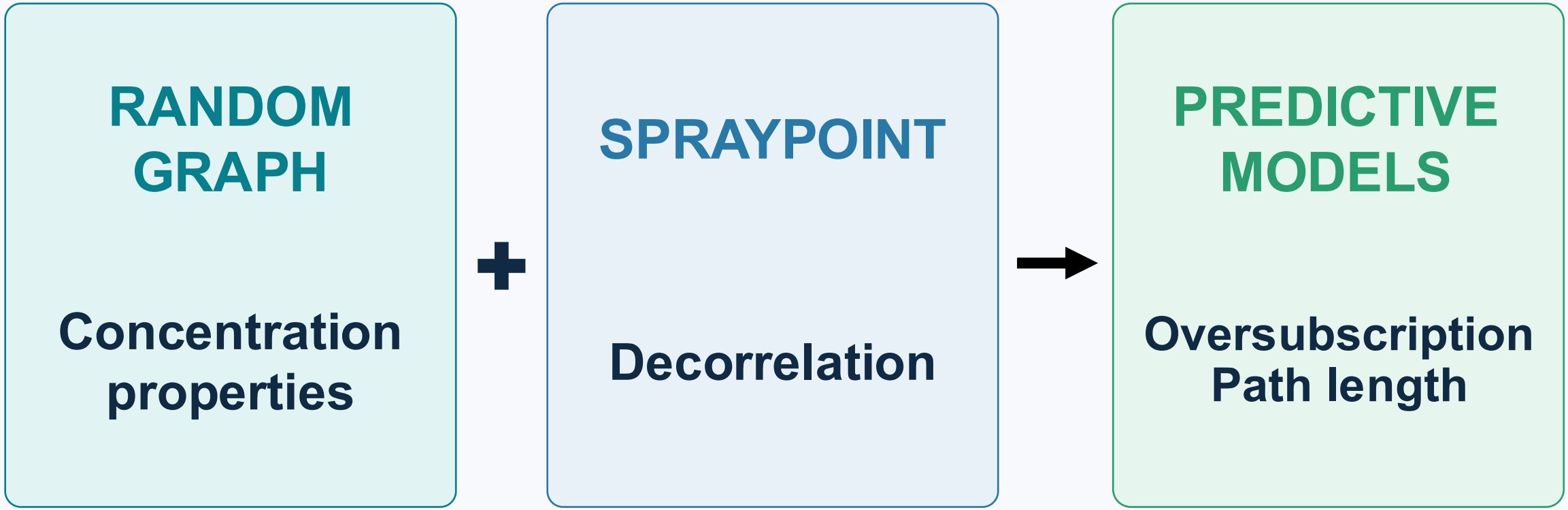
Spraypoint finds almost every available path



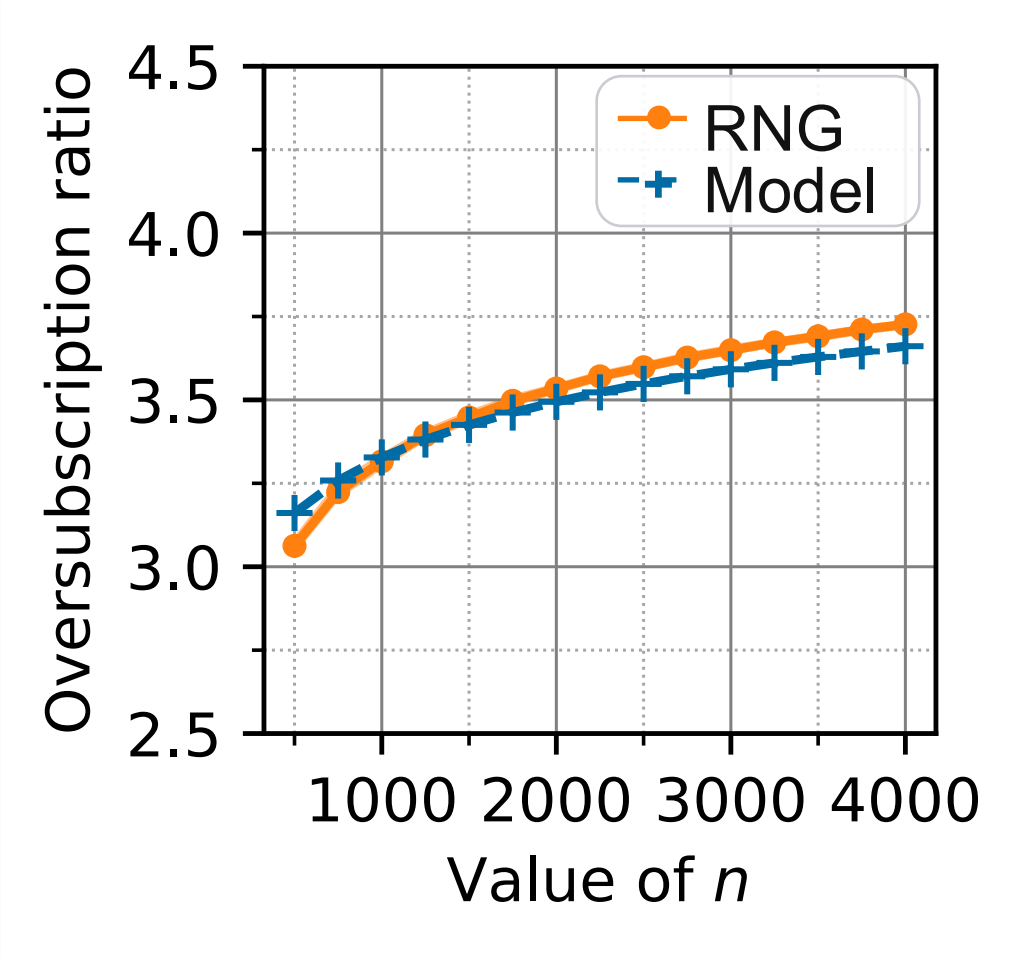
Modeling: Need predictable performance



RNG models enable predictable topology design



RNG models enable predictable topology design



Number of servers, oversubscription

↓

Topology parameters (n=1000, d=64, p=4)

Path to production

Start research — 2022

Two experimental fabrics — 2024

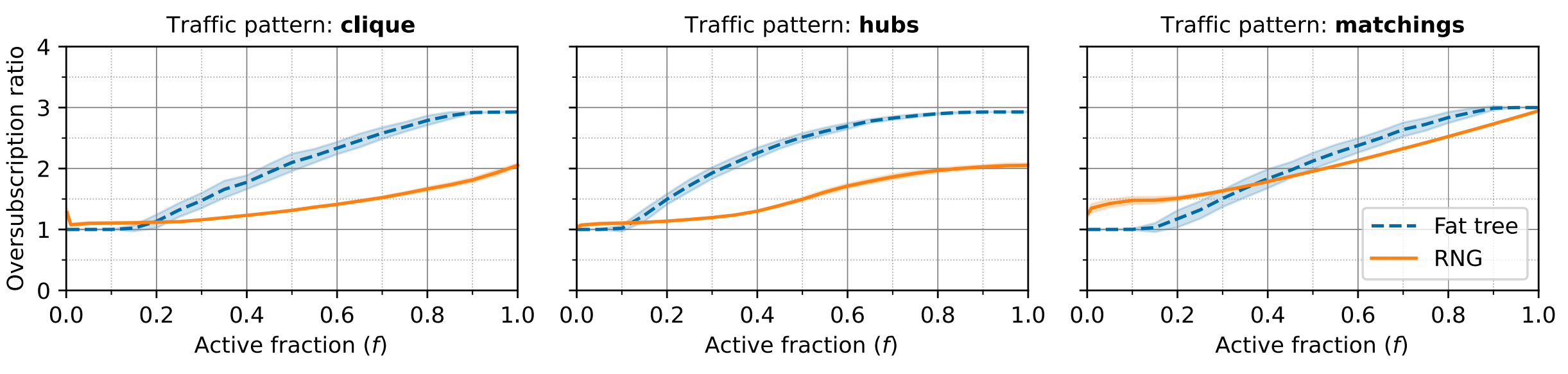
Tore them down — ×

Two production fabrics — 2025

Default for new fabrics — ✓

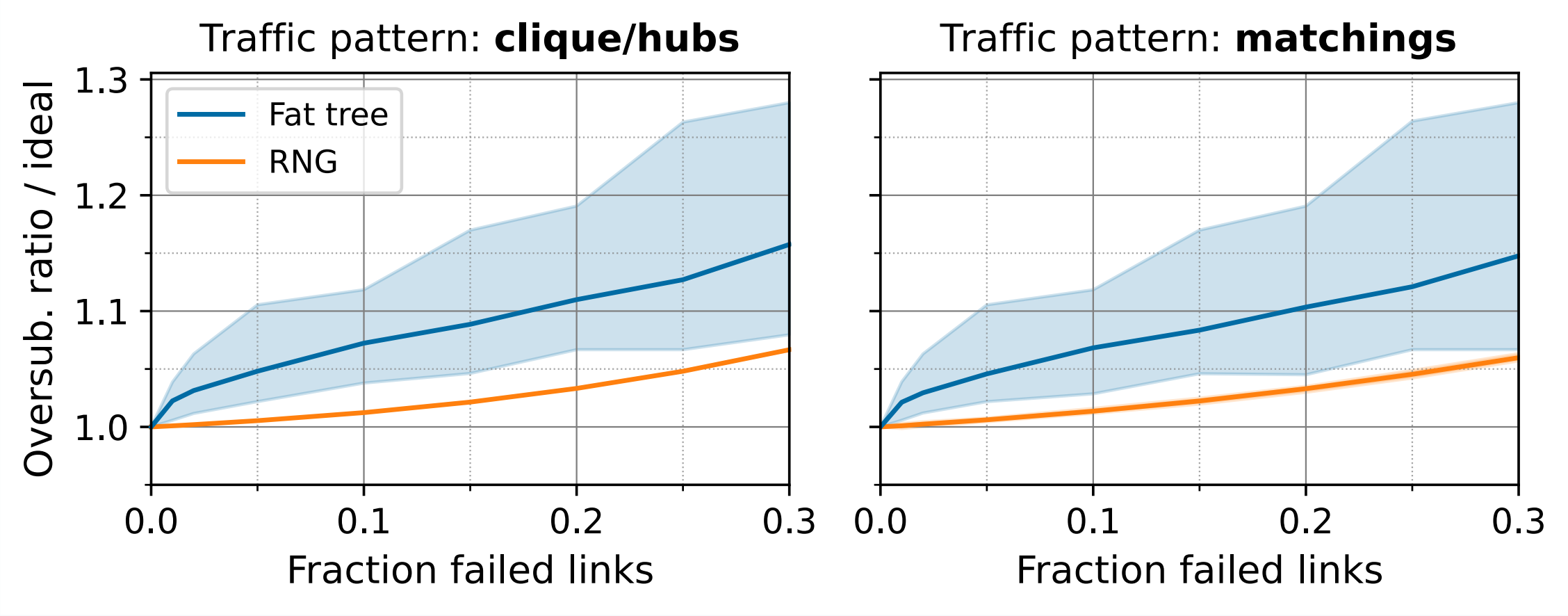


RNG offers generally better throughput



Lower is better

Failures degrade performance gracefully in RNG



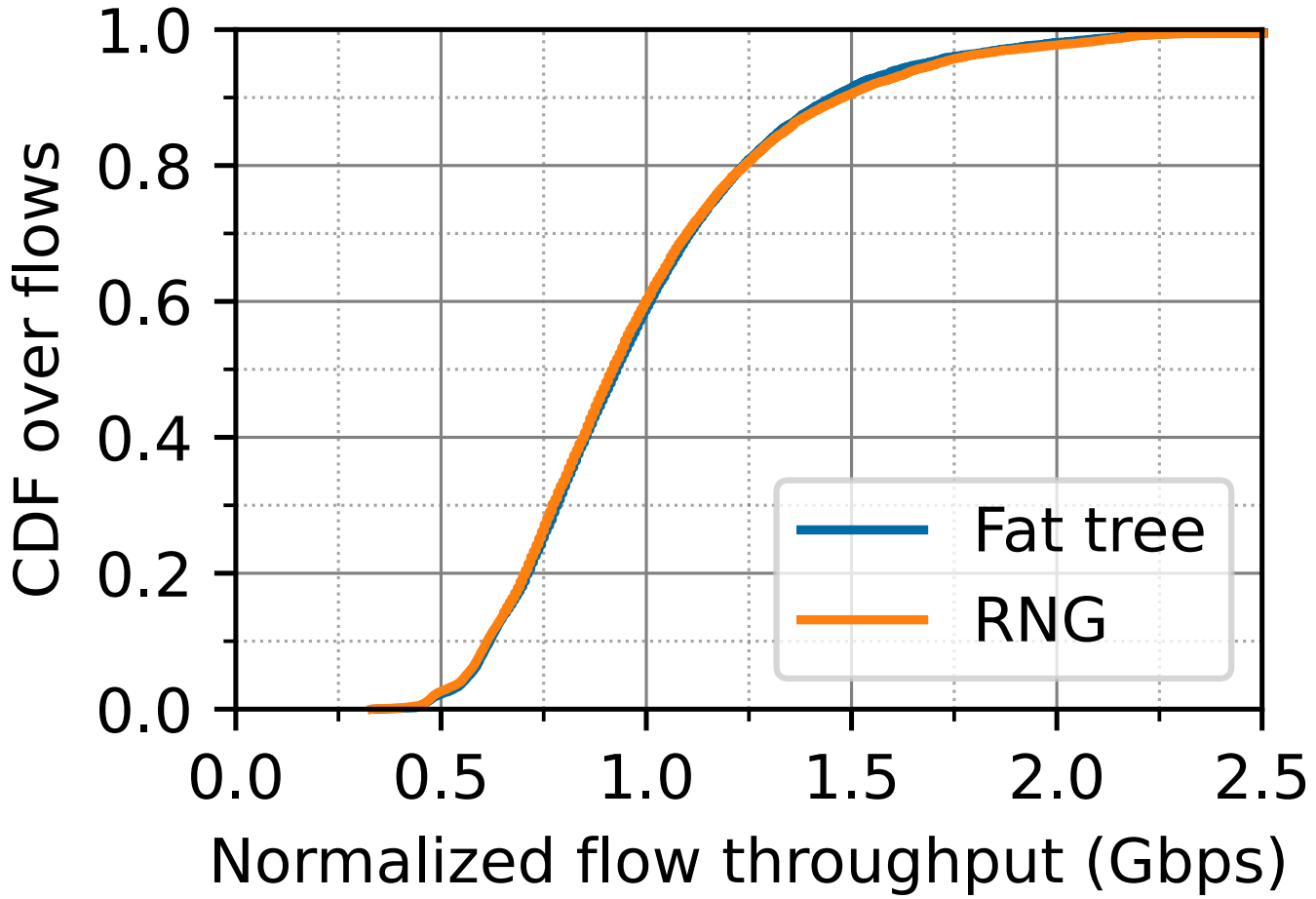
RNG enables flat datacenter networks



ShuffleBox	Spraypoint	Predictive models
69% fewer switches	**40%** less power	**27%** lower cost

Backup

Application flows perform just as well on RNG



RNG needs 9–45% fewer switches

