Network Defragmentation in Virtualized Data Centers

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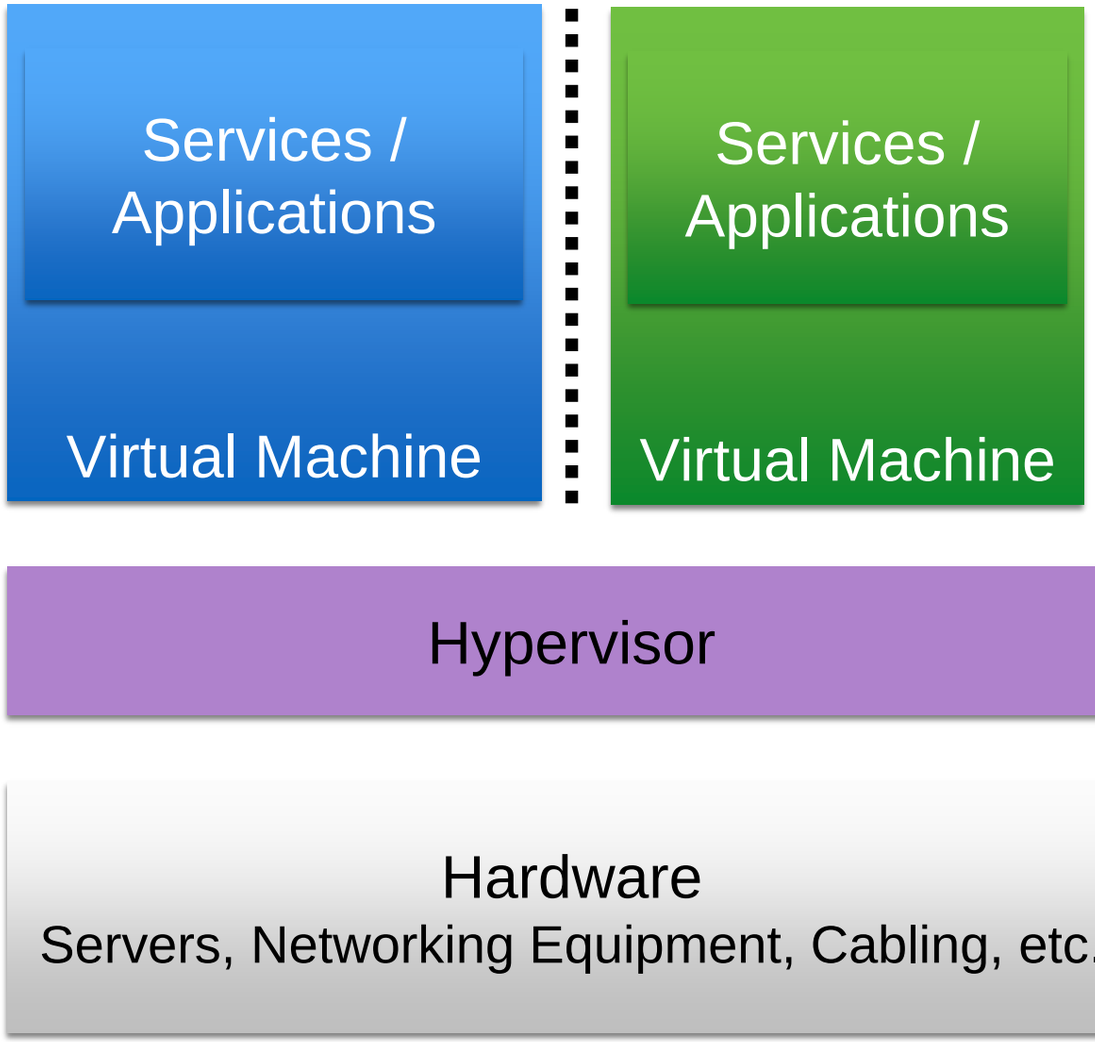
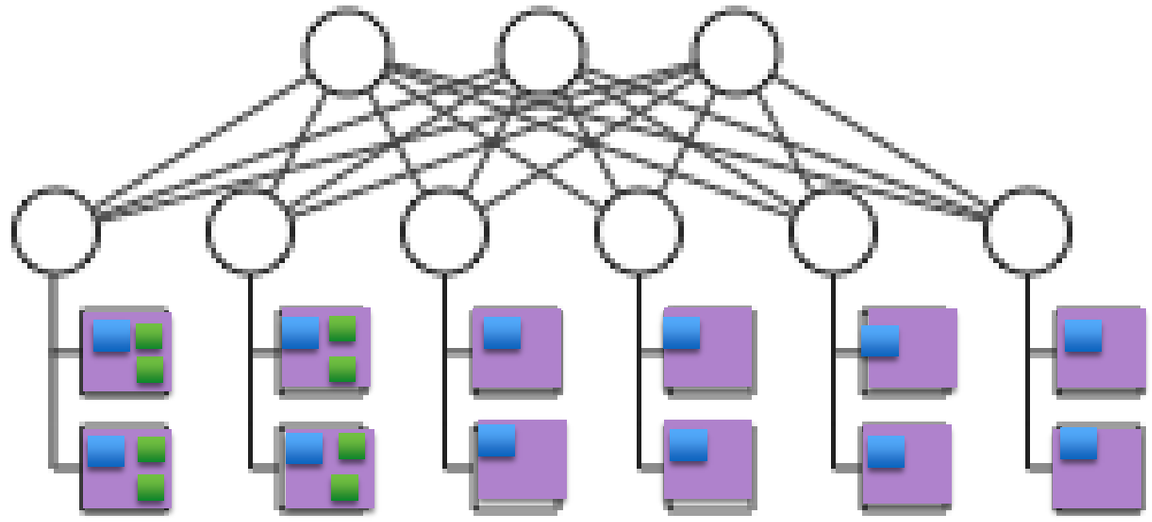
Virtualized Data Centers





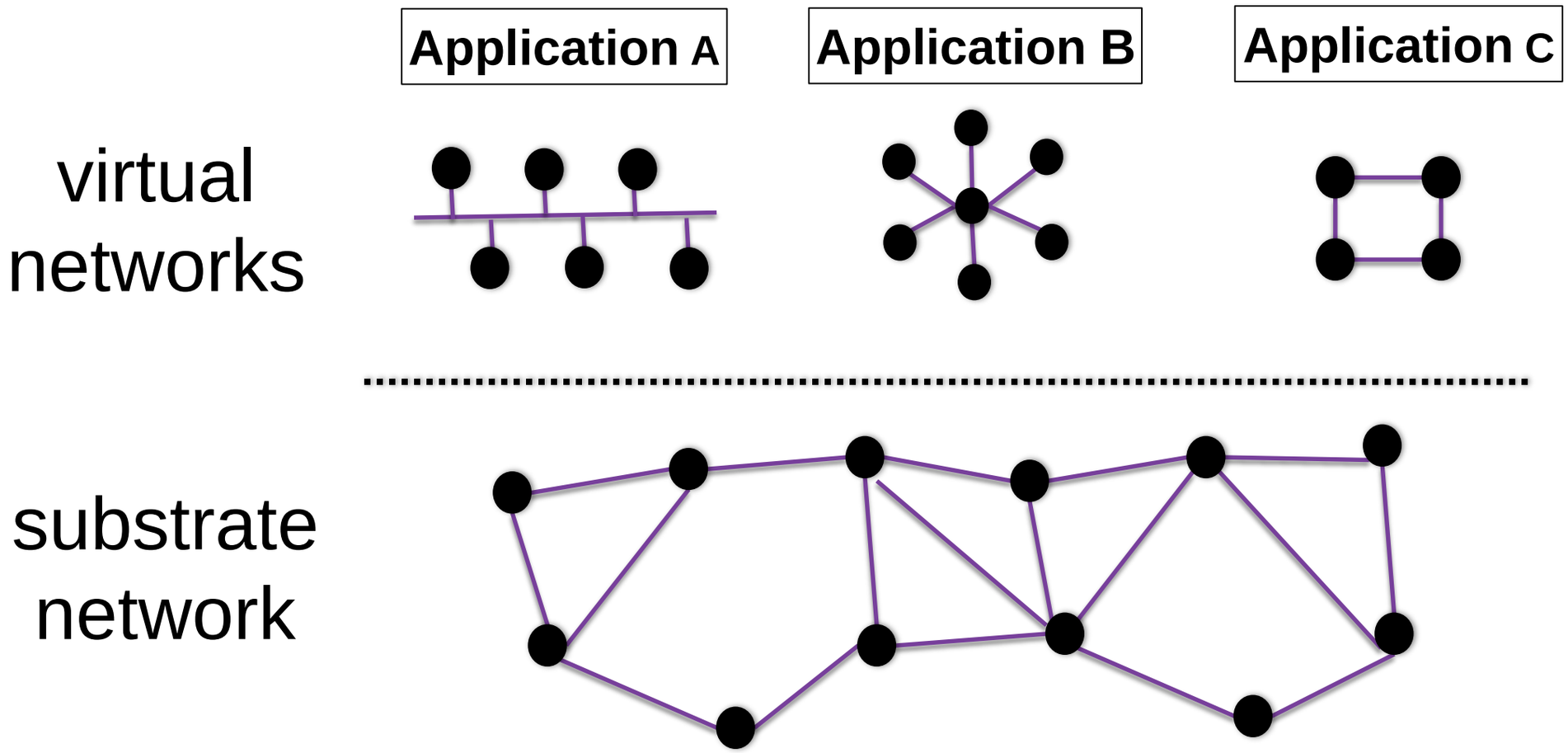
Virtualized Data Centers

- Cornerstone of **cloud computing**
- Coexistence of tenants on **shared** infrastructure
- **Scaling** of resources based on demand

Elasticity is one of its key drivers

New requirement: network virtualization

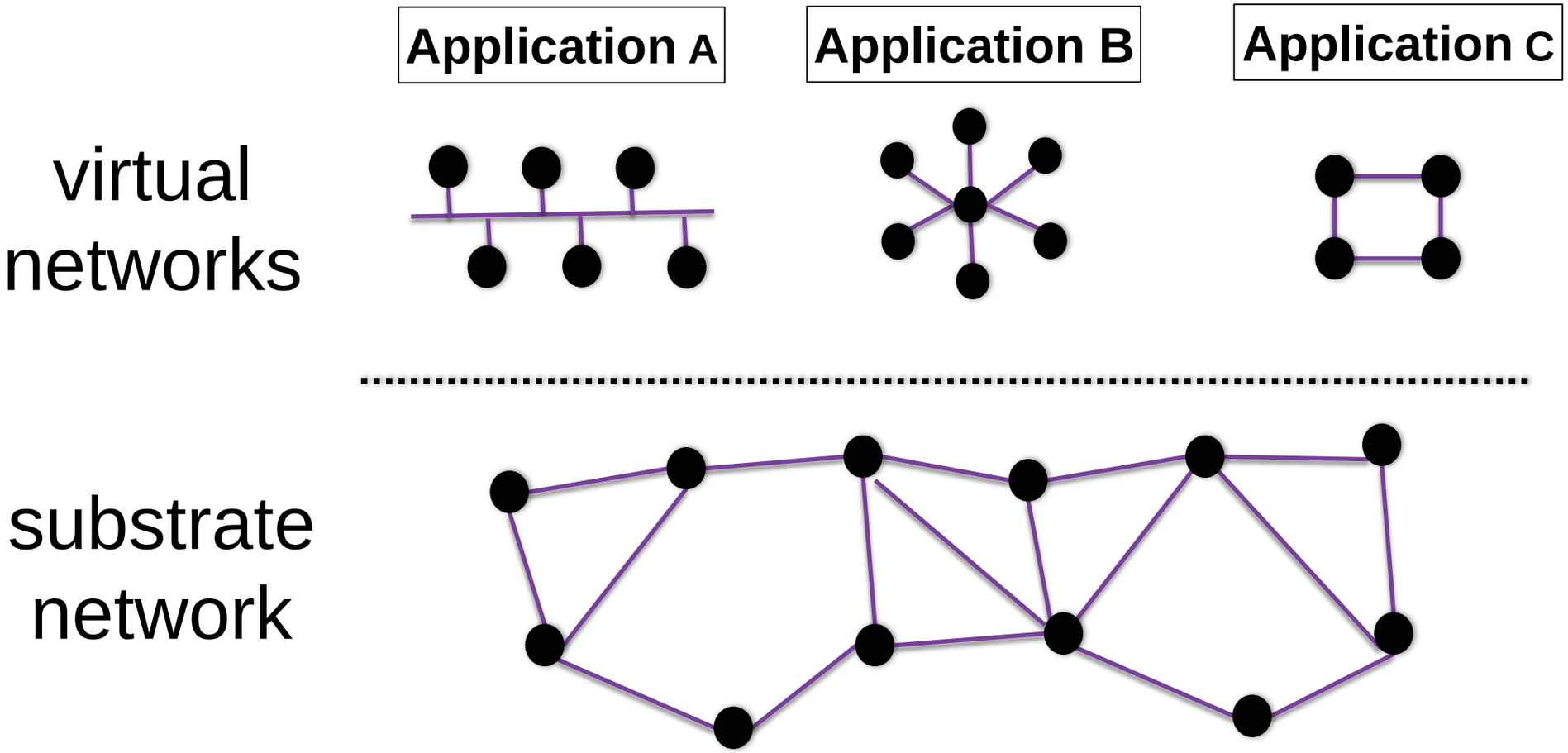
- **Different** cloud applications require **different** topologies and **different** network guarantees



- A reality today: VMware NVP [NSDI'14], Microsoft AccelNet [NSDI'18], Google Andromeda [NSDI'18]

Limitations of existing approaches

- Core algorithmic challenge: **Virtual Network Embedding (VNE)**
  - Map the virtual network requests onto the substrate infrastructure



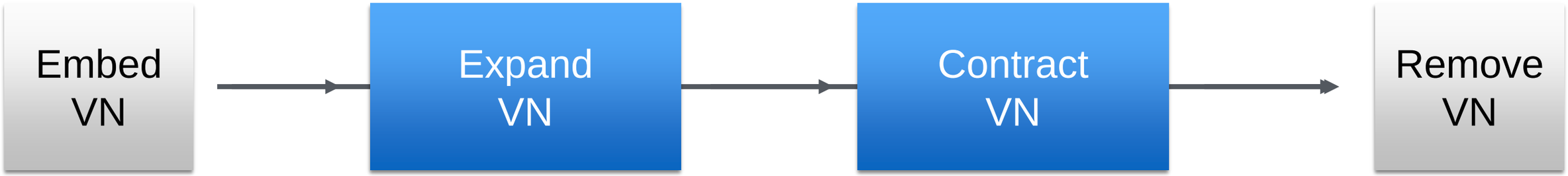
Existing VNE approaches lack a fundamental requirement: <u>elasticity</u>

Contribution #1: new scaling primitives to VNE

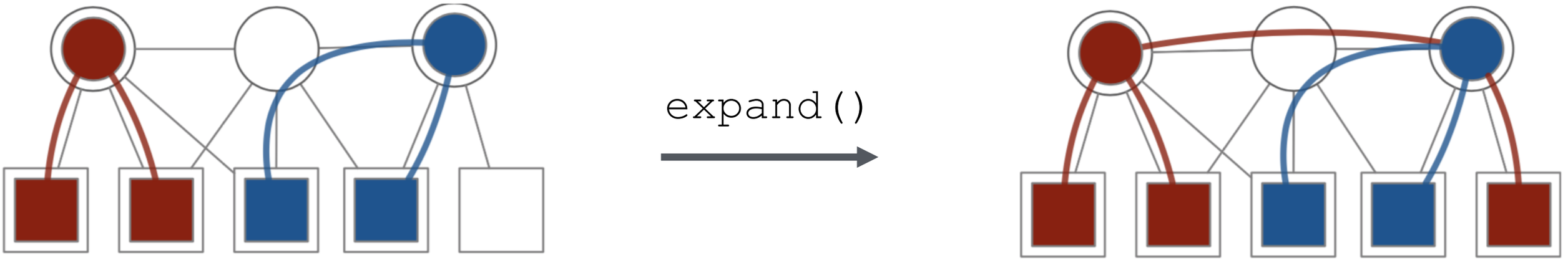
Expand VN / Contract VN

Problem: network fragmentation

Virtual Network Lifecycle



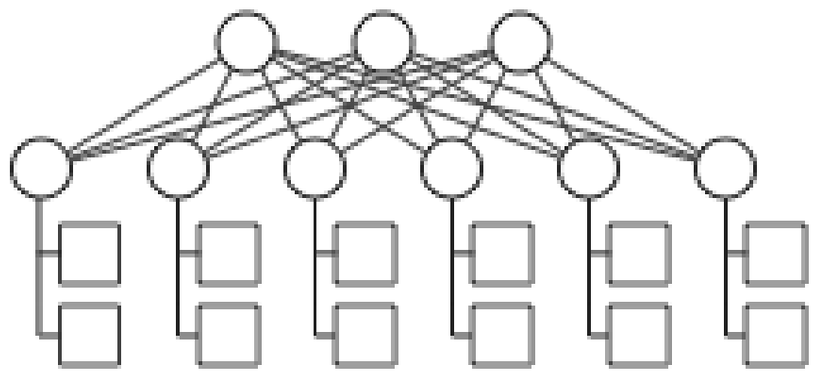
Problem: network fragmentation



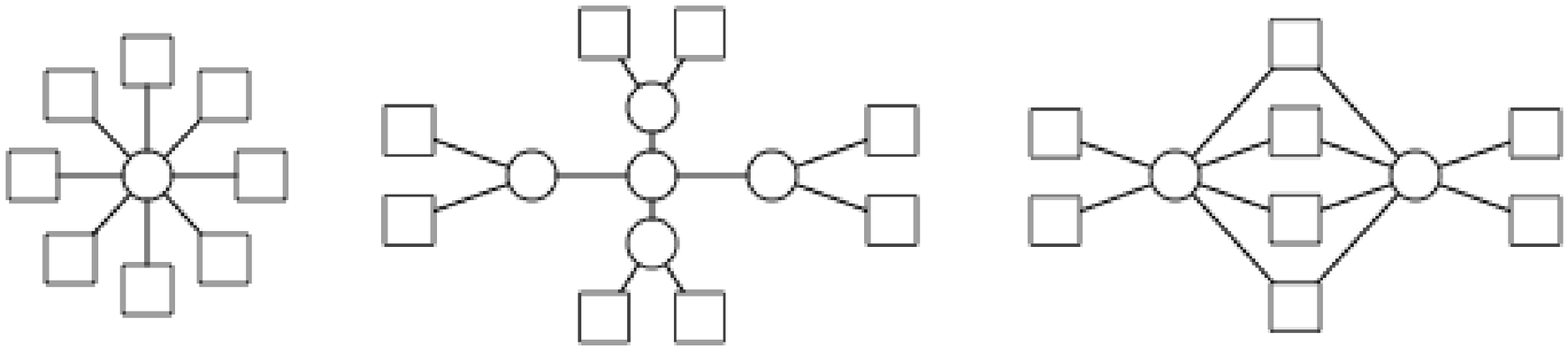
- Fragmentation introduces several **problems**
  - Longer path lengths, higher latencies
  - Harder to map new VNs, lower acceptance ratios

Implementation

- Extended an existing VNE algorithm [Ballani11] with expand and contract primitives
- Cloud simulator
  - Leaf-Spine physical topology
  - Different virtual topologies



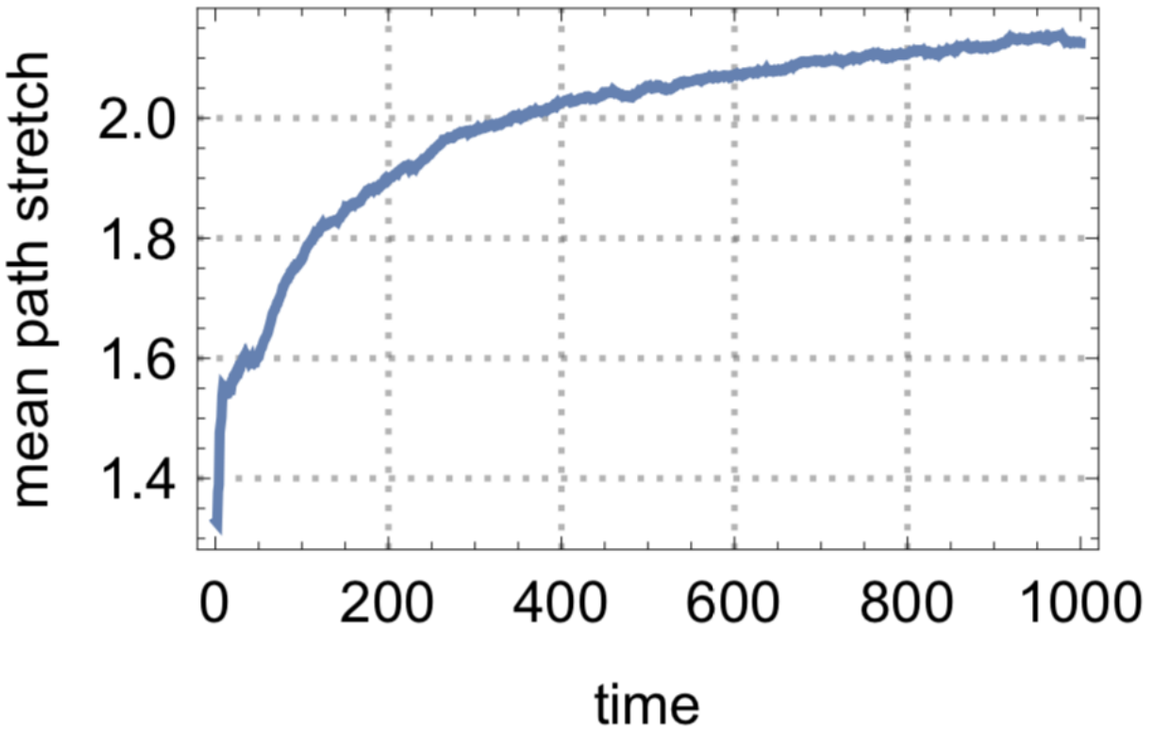
Leaf-Spine Physical Network Topology

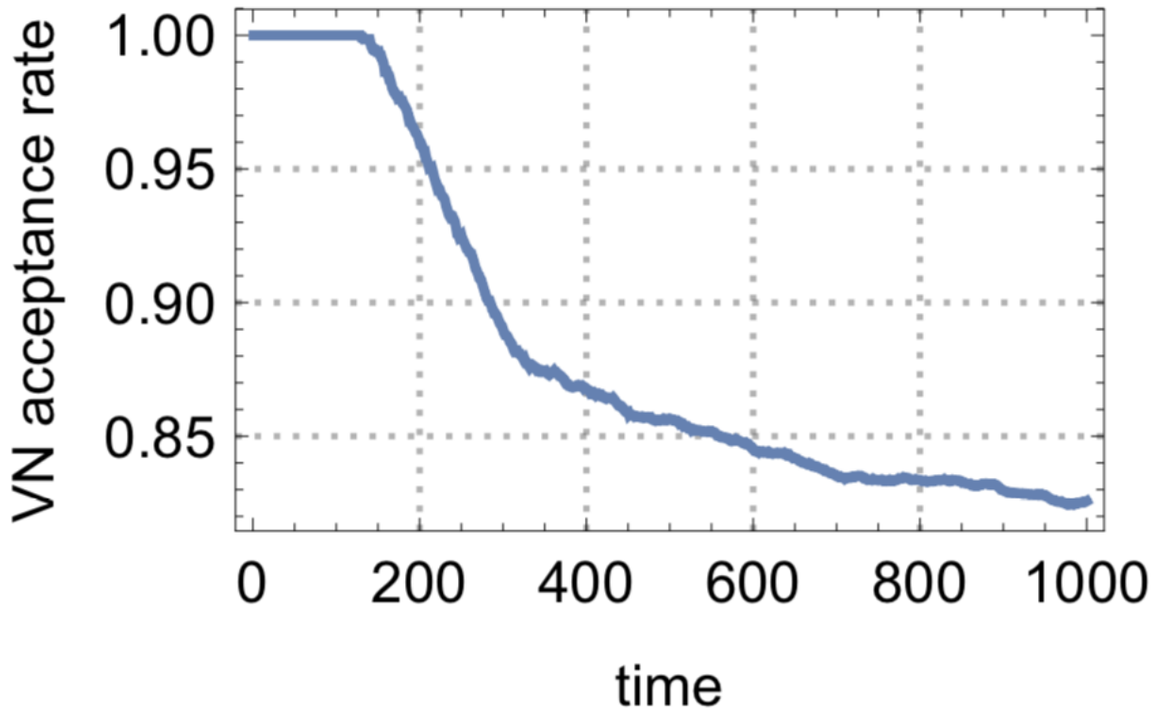


Virtual Network Topologies: VC, VOC, 3T

Costs of fragmentation

- **Simulation:** leaf-spine topology; 28 switches and 384 servers; adding, deleting, expanding, or contracting virtual networks 1000 times (averaged over 10 runs; randomized workloads)





- **Longer path lengths** -> higher latencies and cost, poorer application performance, prolonged job completion times
- **Lower acceptance ratios** -> reduced revenue

Contribution #2: new management primitive

Expand VN / Contract VN

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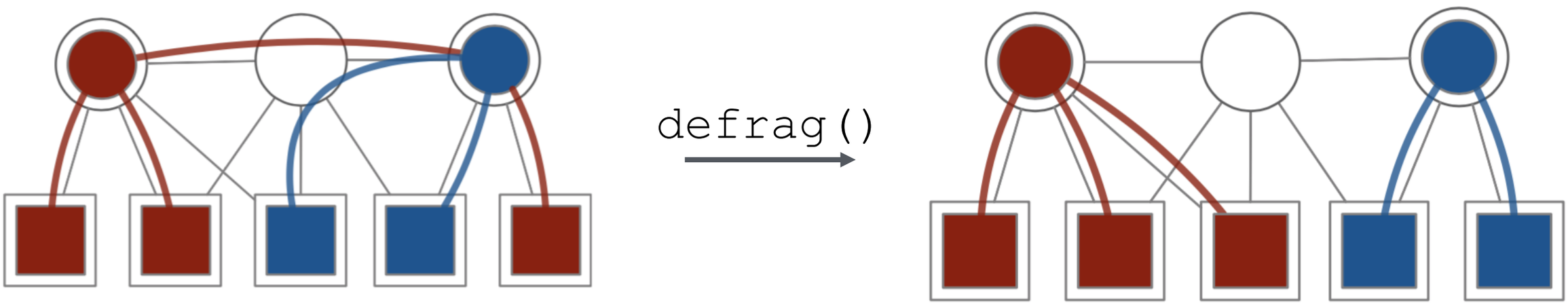
Network defragmentation

Network Defragmentation

- Optimize VNE algorithms to avoid fragmentation?
  - Hard: no prior knowledge of upcoming request

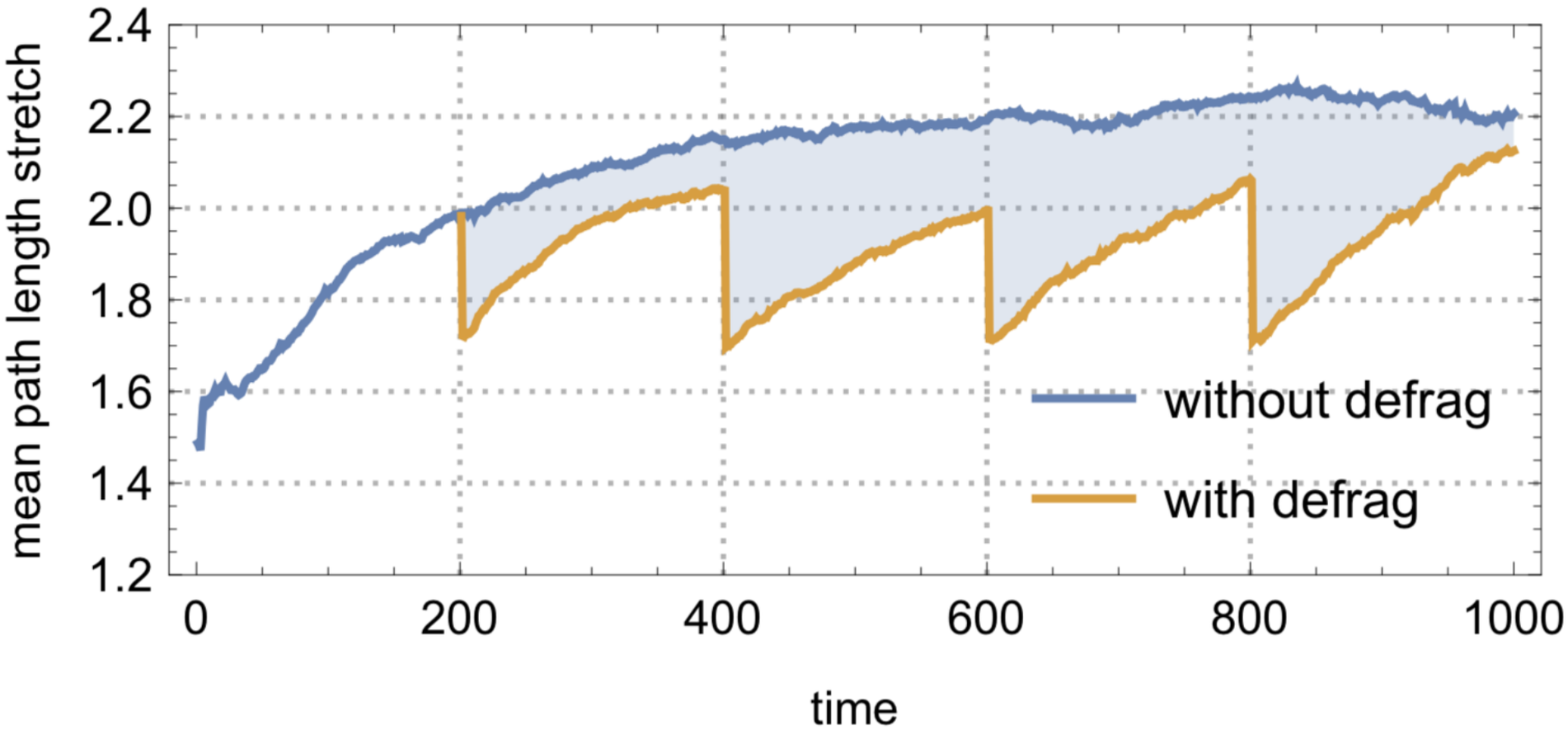
We explore a diferente approach: **explicit defragmentation** by periodically running a **network migration** algorithm (e.g., LIME [SOCC14])



Network defragmentation heuristic

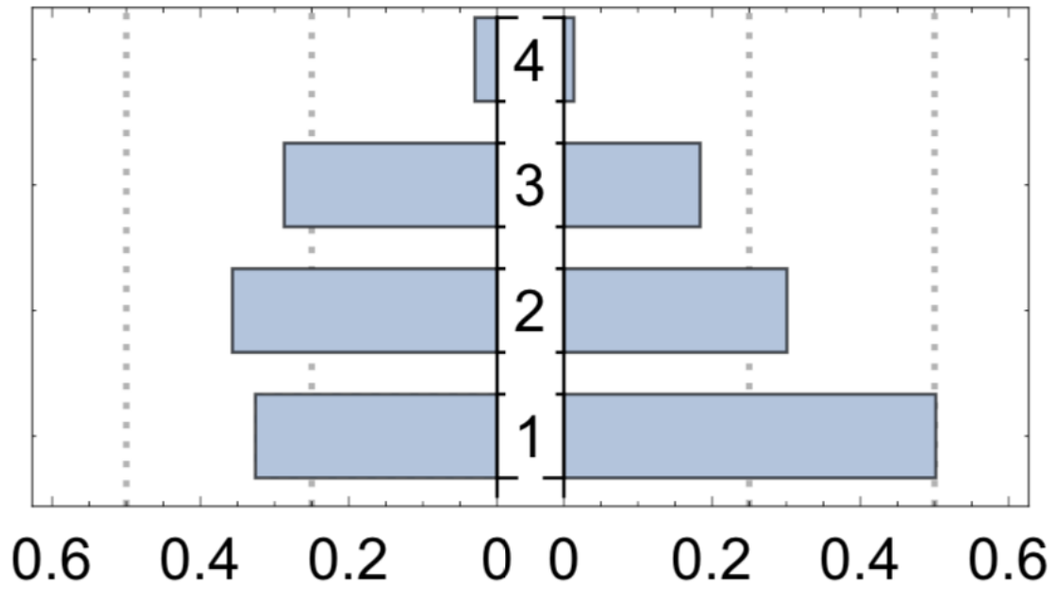
- (Naive) remap of all virtual networks
  1. Unmap all VNs
  2. Sort by VN size (biggest to smallest)
  3. Re-embed each VN in order

Evaluation: mean path length stretch



Evaluation: fraction of paths by path length

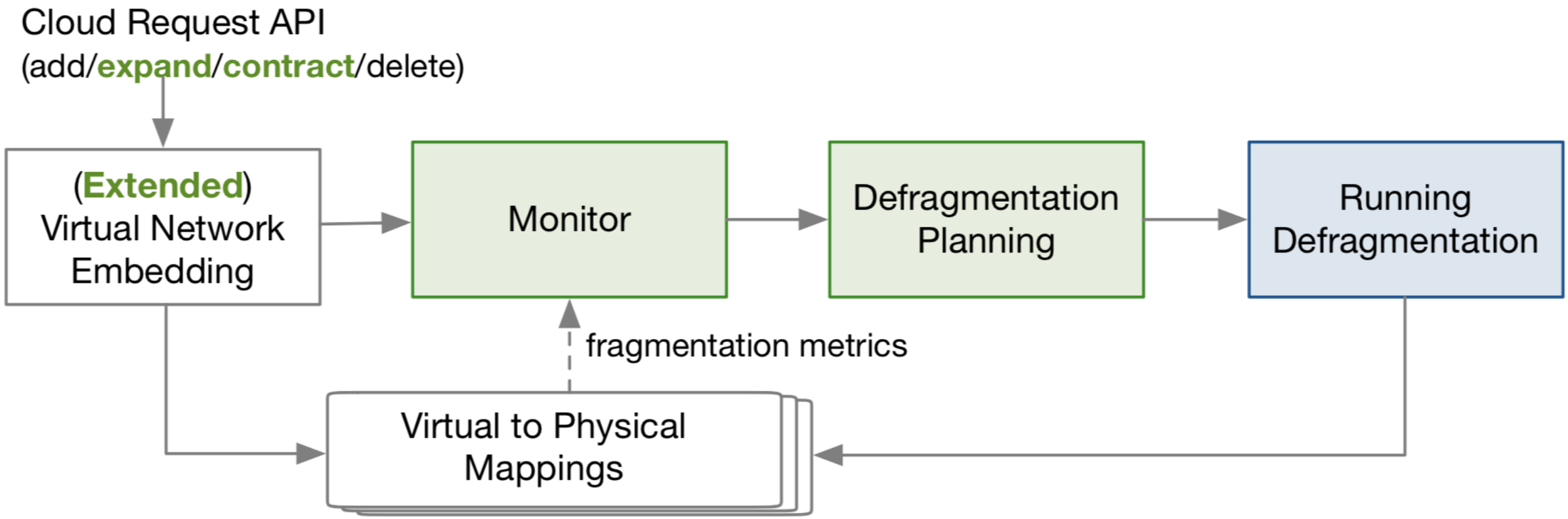
before defrag



after defrag

Lower path lengths reduce latencies and cost, improve application performance, and by improving efficiency increase provider profit

Summary



- Future work
  - better defragmentation heuristics that minimize migration cost
  - integration with network migration

THANKS.
QUESTIONS?

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