Parallelizing Packet Processing in Container Overlay Networks

(EuroSys '21)

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[2]*The University of Texas at Arlington*
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- Lightweight
- OS level virtualization
- **High** application density
- **Efficient** resource utilization

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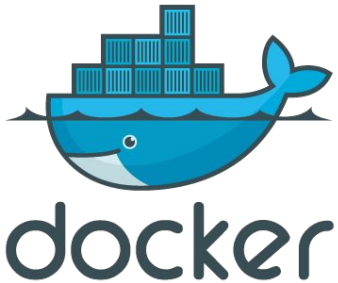
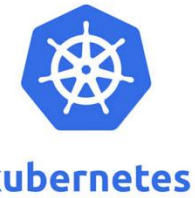
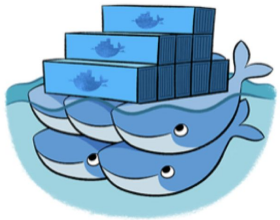




Based on report, Google launches over **7k+** containers **per sec** for its searching service.

How do containers communicate?

- **Overlay networks** provide connectivity
- Typical solutions: Docker Overlay, Flannel, Calico, Weave…
- Generally build upon a tunneling approach like **VxLAN** protocol



flannel

PROJECT CALICO

weaveworks

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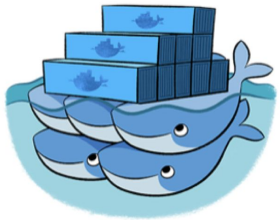

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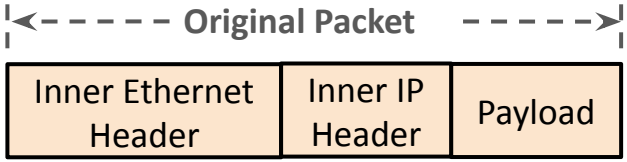

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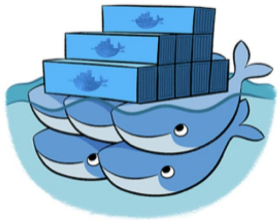

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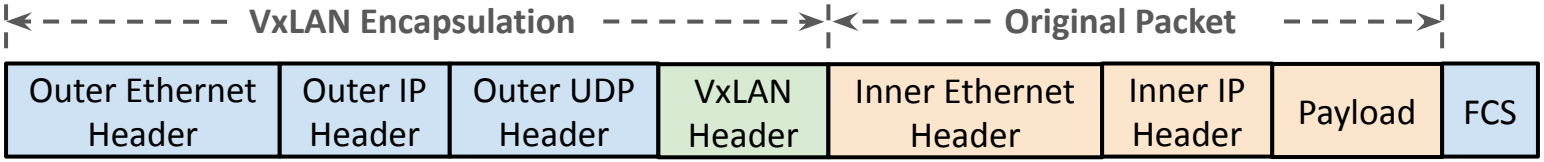

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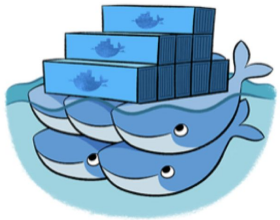

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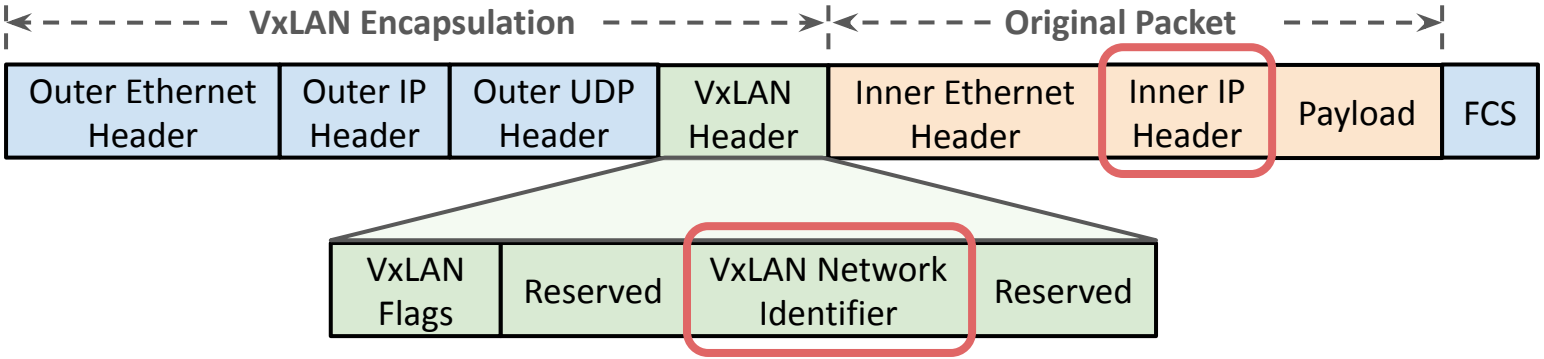

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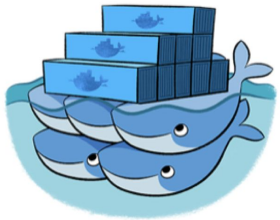

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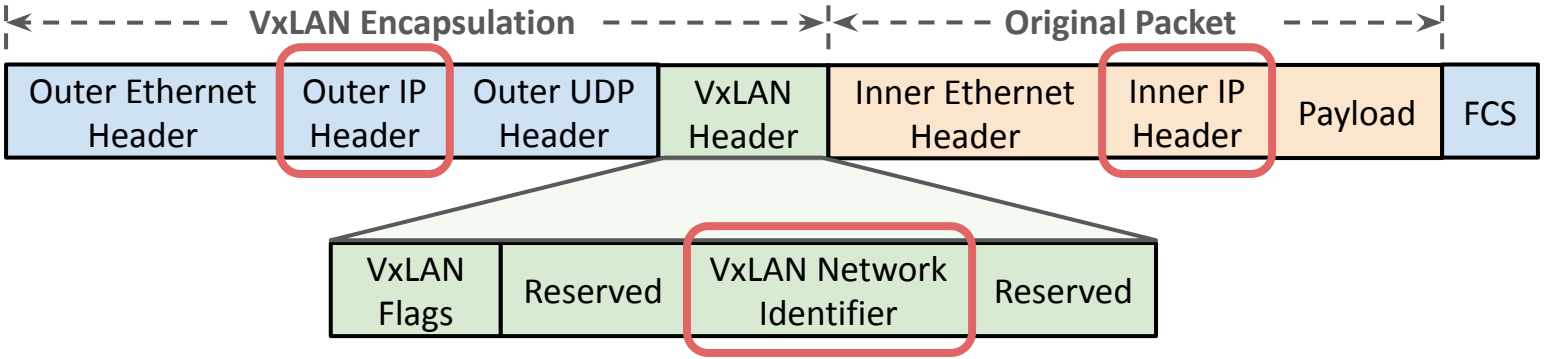
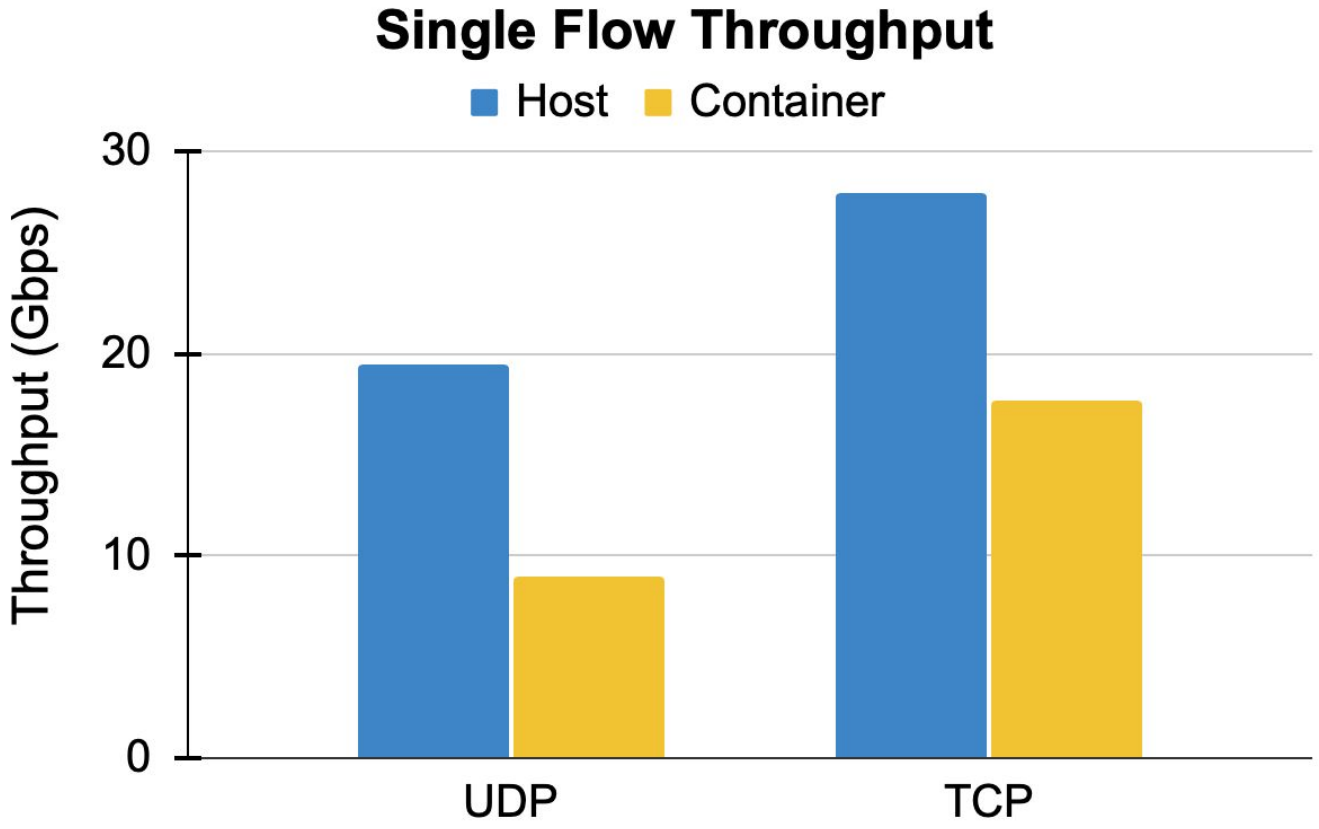


Performance overhead of overlay networks

- Machines are connected via a 100 GbE NIC.



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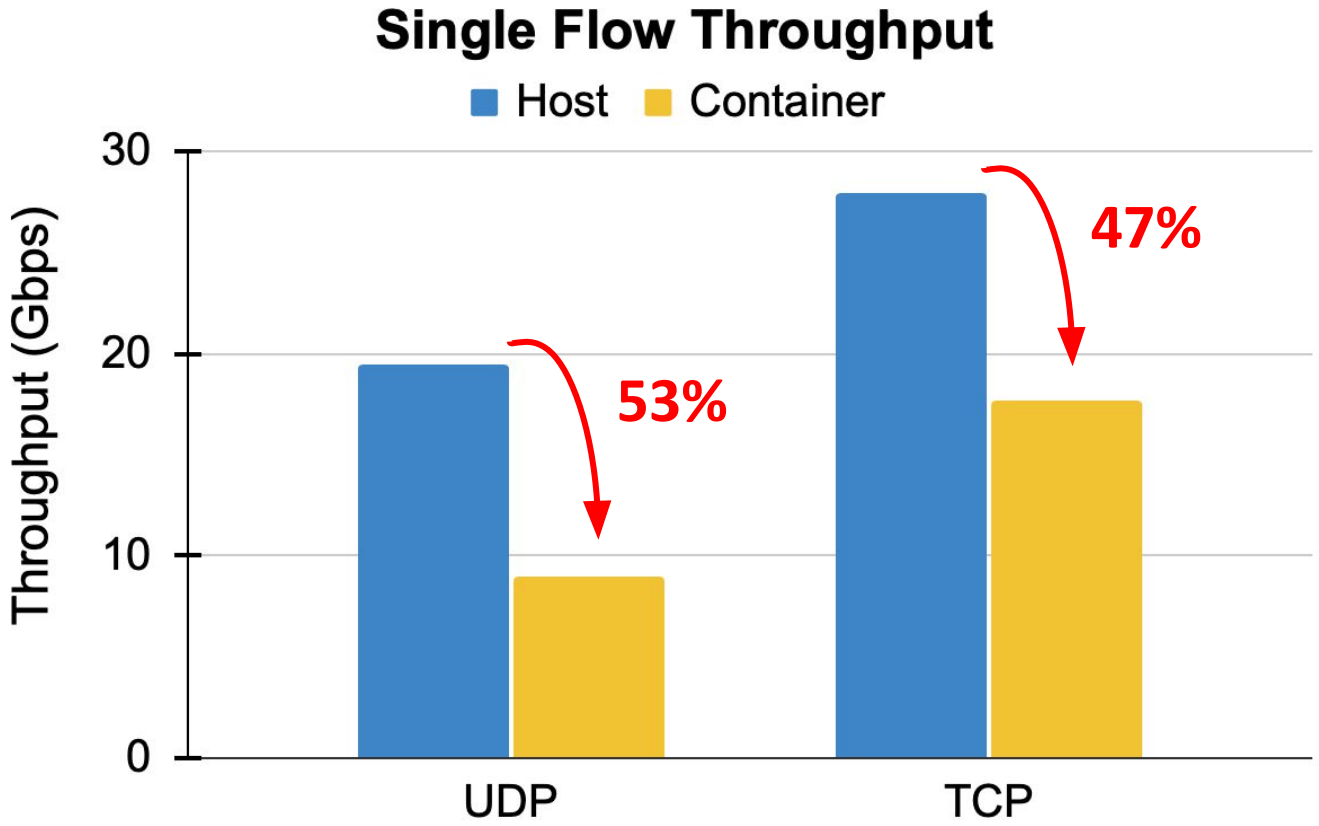

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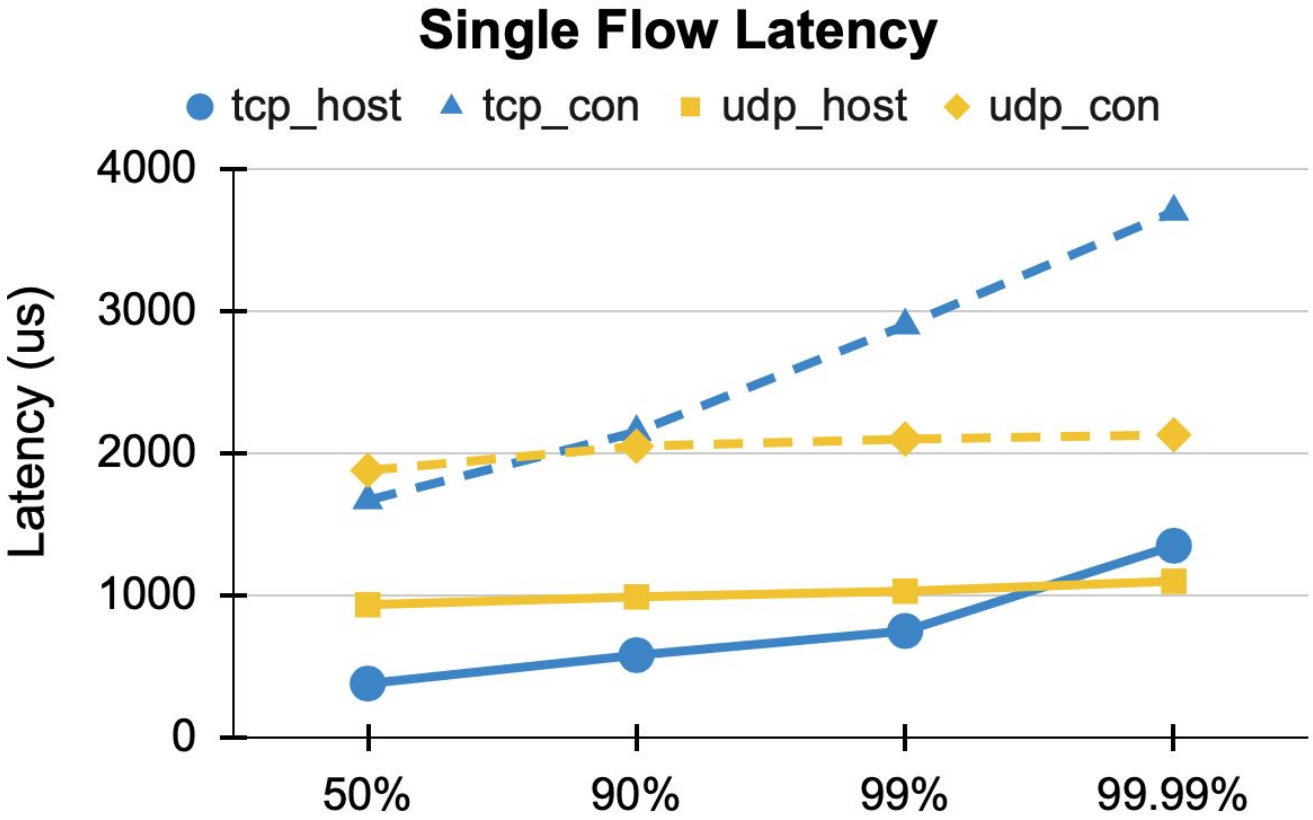

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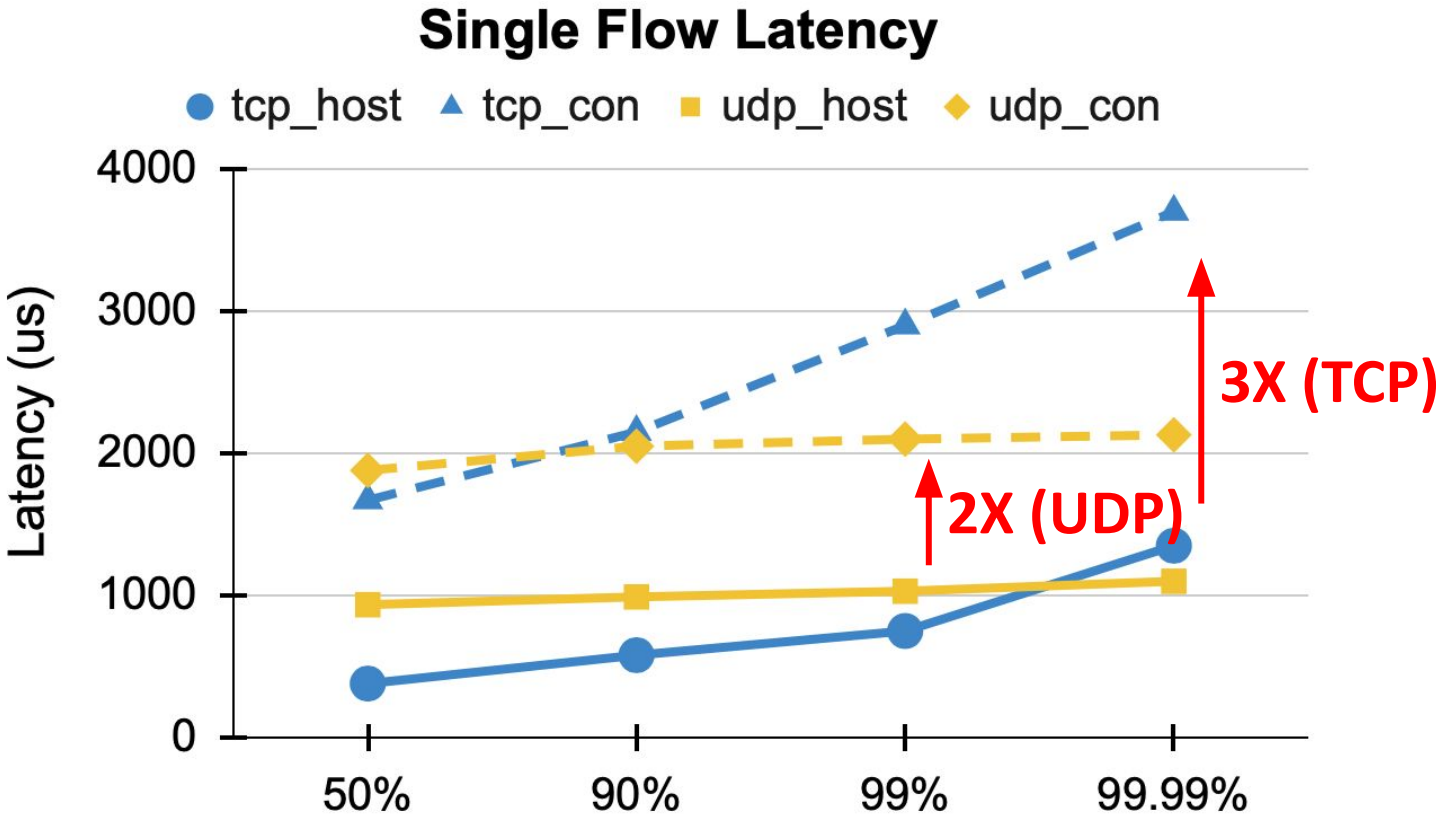

Why is overlay network slow?

L 7

L 3&4

L 2

Hardware

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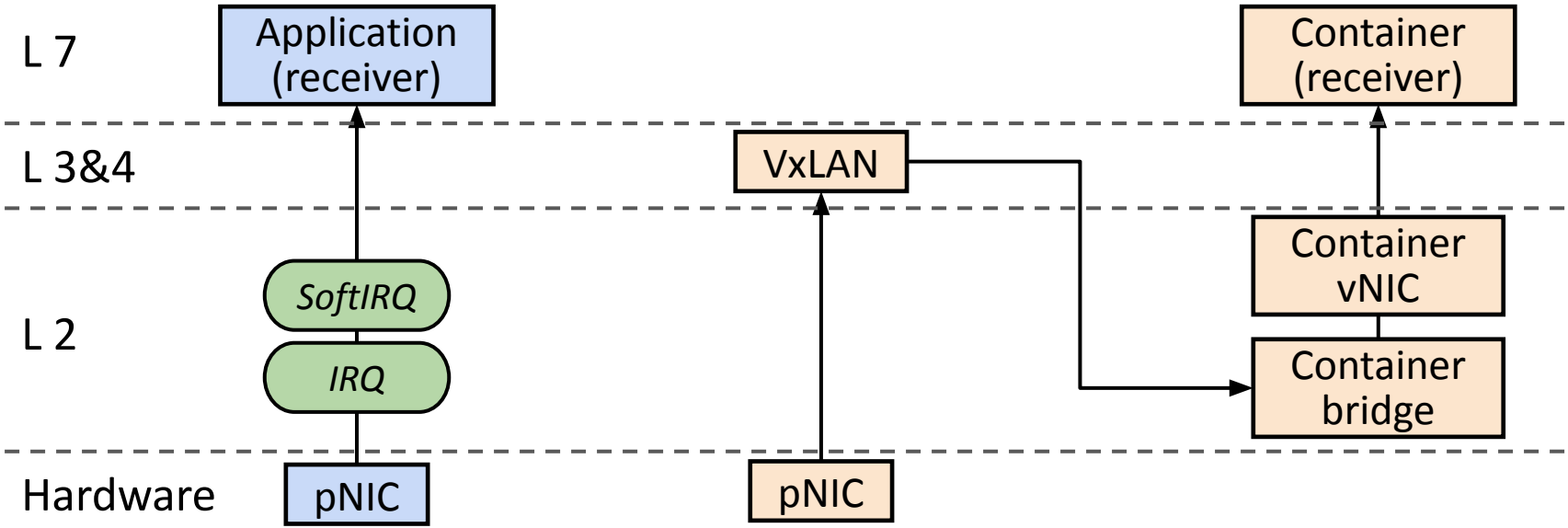

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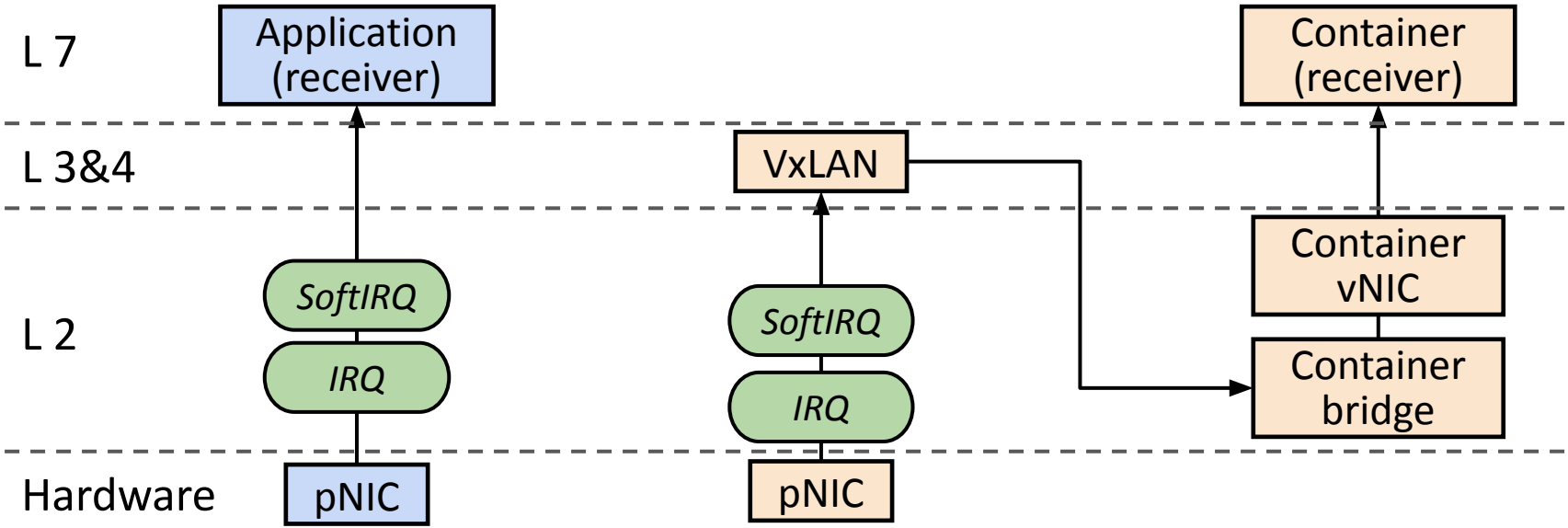

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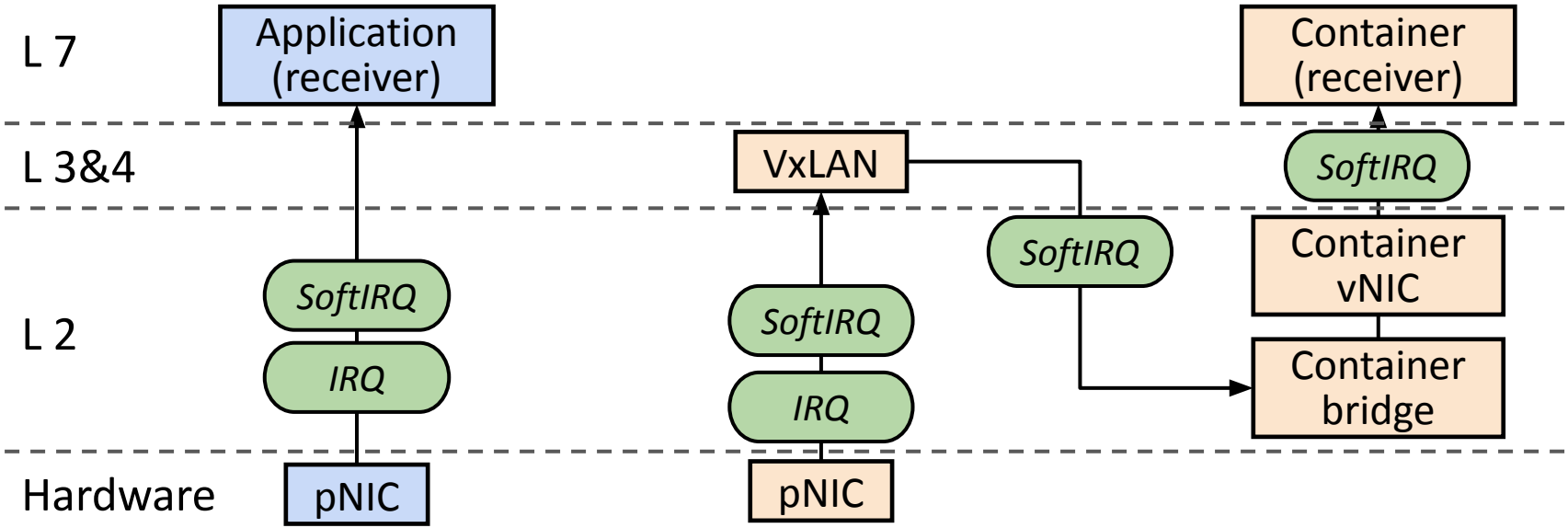

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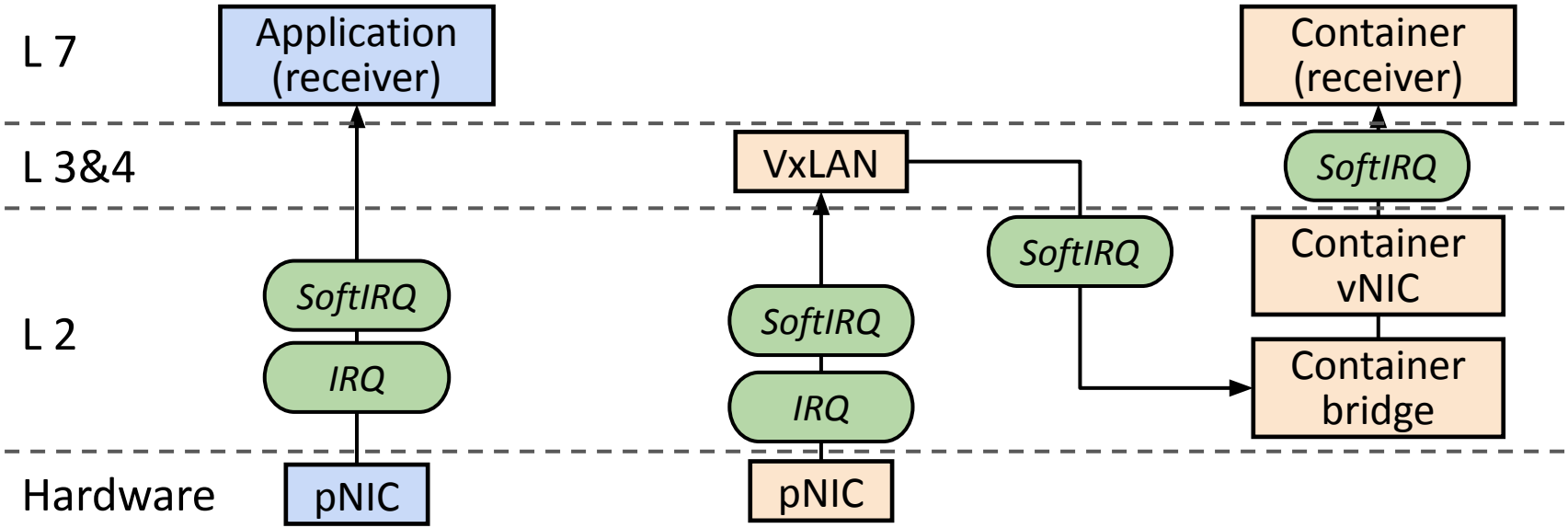

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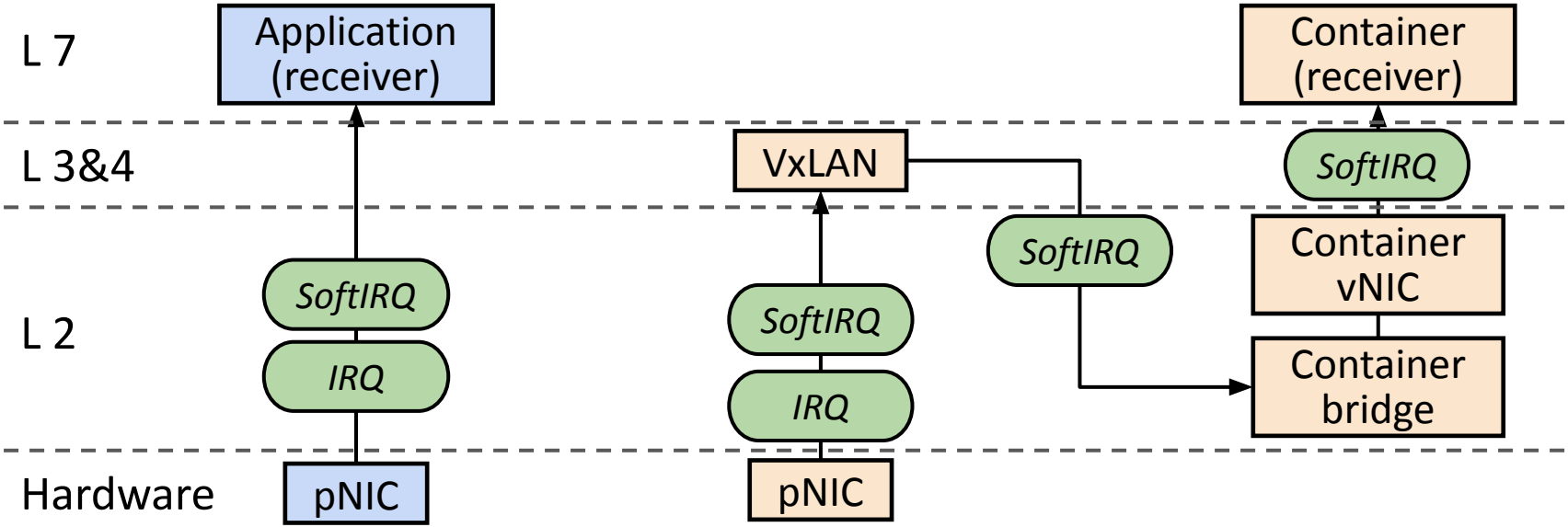
- **Overhead**
  - **Additional** devices
  - **Prolonged** path
  - **Excessive and serialized** softIRQs



Existing solutions to accelerate overlay networks

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- Hardware offload (Mellanox ASAP^2, AccelNet*[NSDI'18]*)
  - ✔ Fastest, completely avoids CPU overheads
  - ❌ Requires new/expensive hardware; SR-IOV limitations

Our solution - FALCON

FALCON = **F**ast and B**al**anced **Co**ntainer **N**etworking

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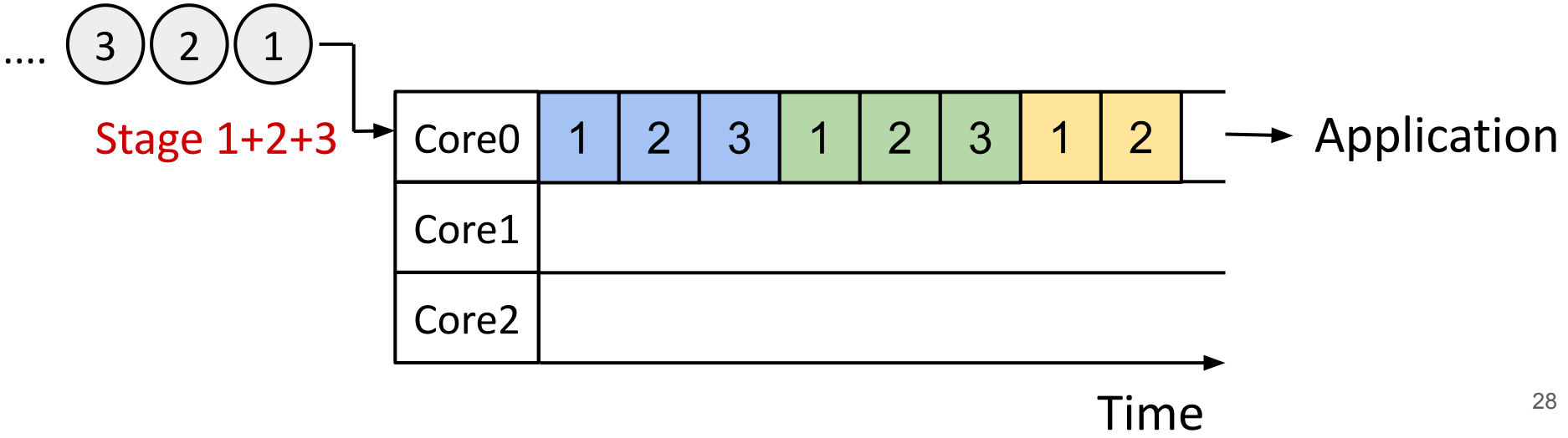
Key idea: Utilize idle CPU resources to accelerate packet processing

- Software-based solution
- Full network isolation / flexibility
- Completely backward compatible
    - Immediately deployable in real systems
- Better performance

FALCON - SoftIRQs Pipelining

- **Blue** - 1st SoftIRQ ; **Green** - 2nd SoftIRQ; **Yellow** - 3rd SoftIRQ



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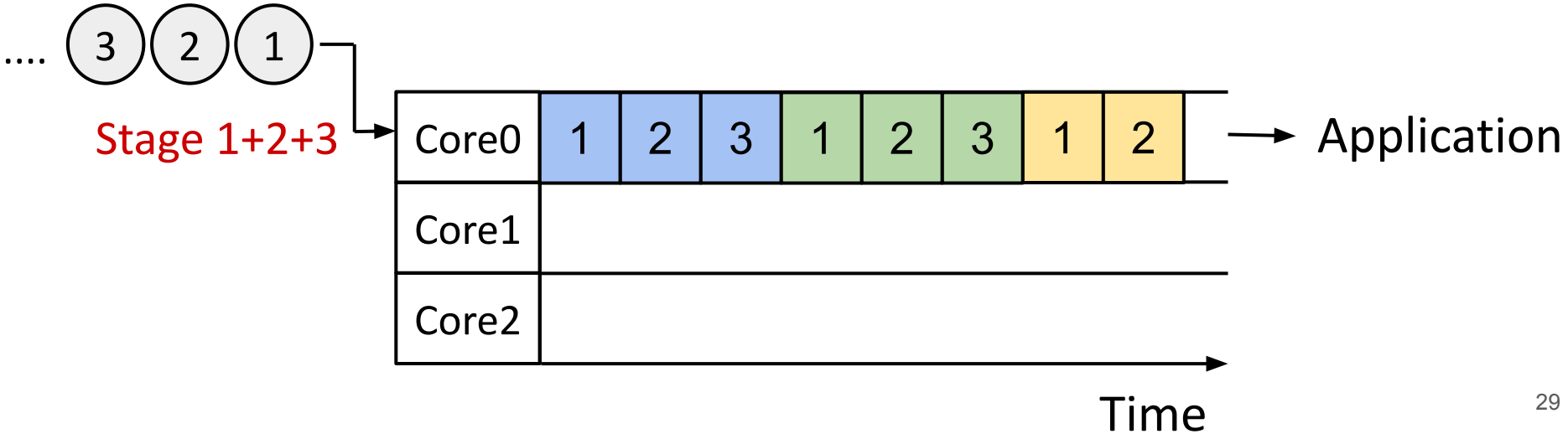
- These 3 stages can be dispatched and parallelized



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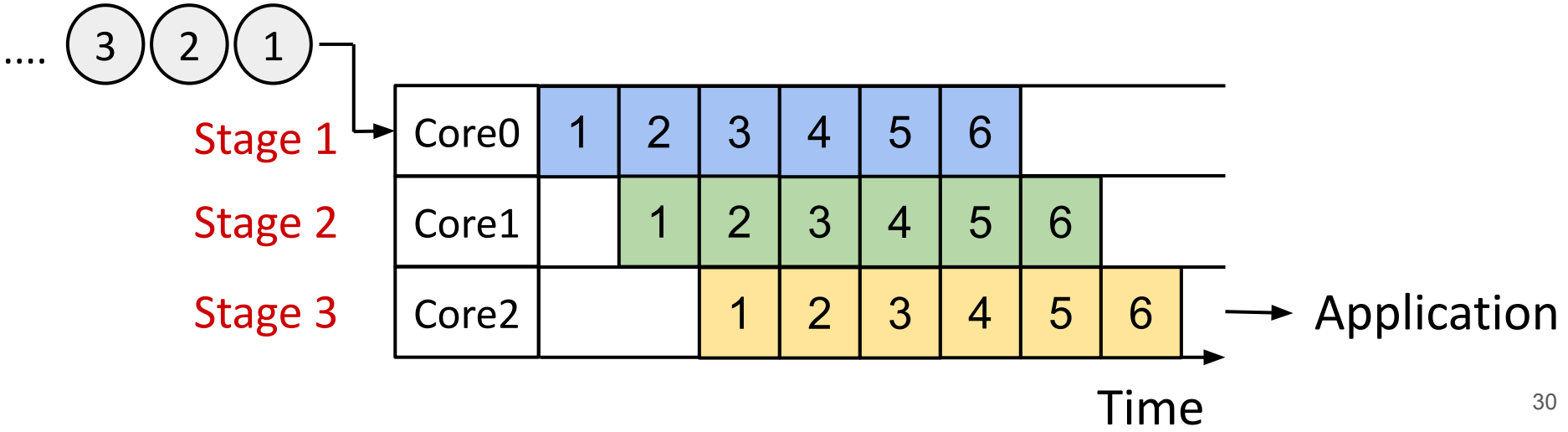

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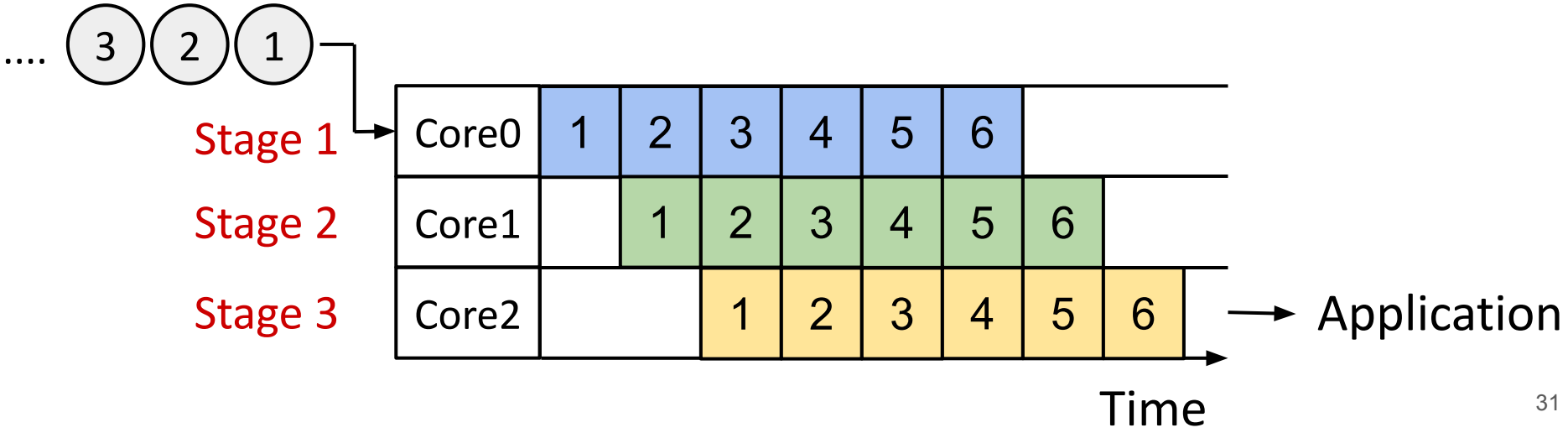

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- Stage transition functions (Hashing)
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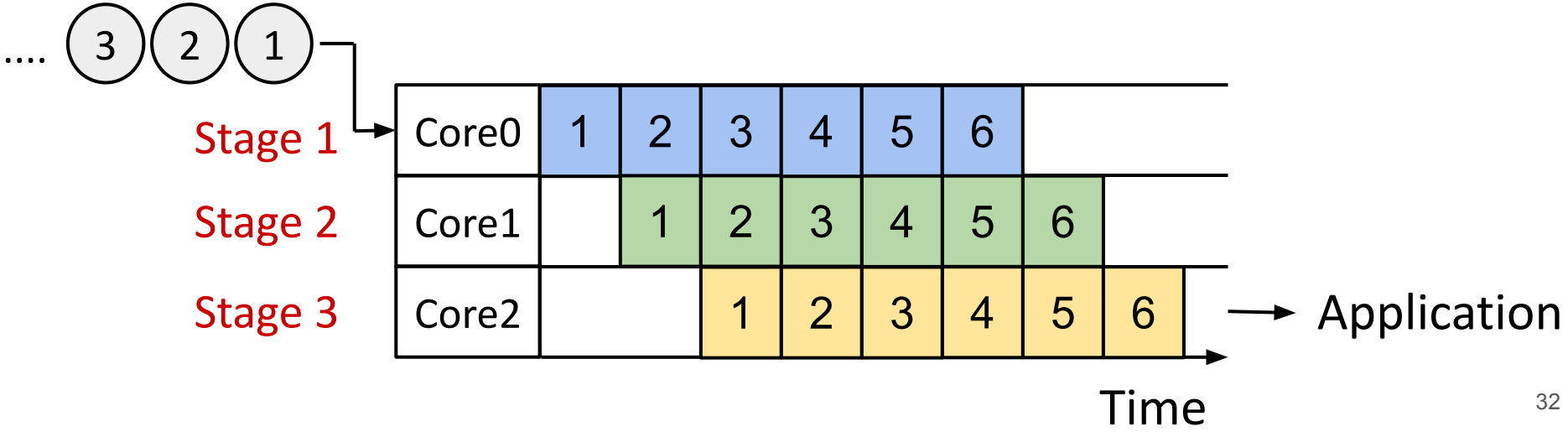
- Parallelization (Overlapping SoftIRQs)
- Maintain In-order



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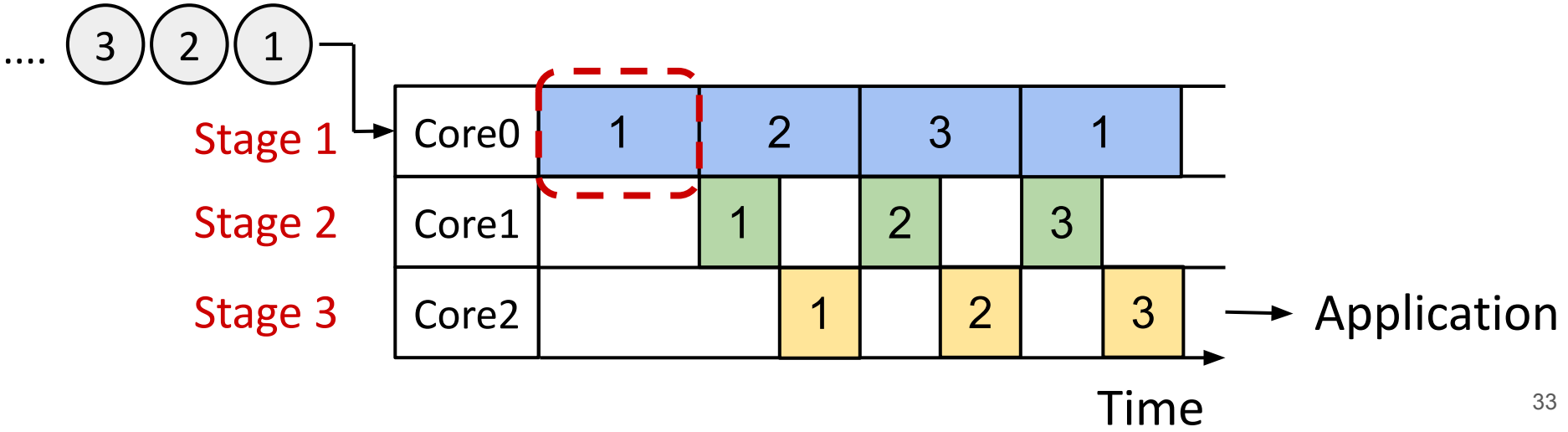

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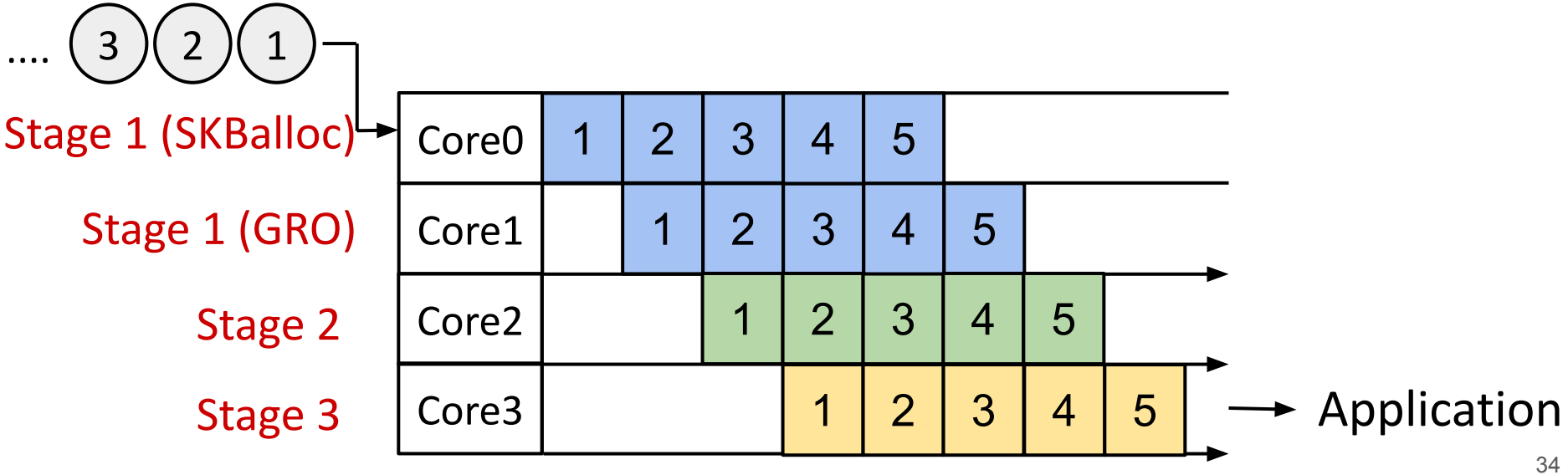
- Enable the transition function when doing GRO



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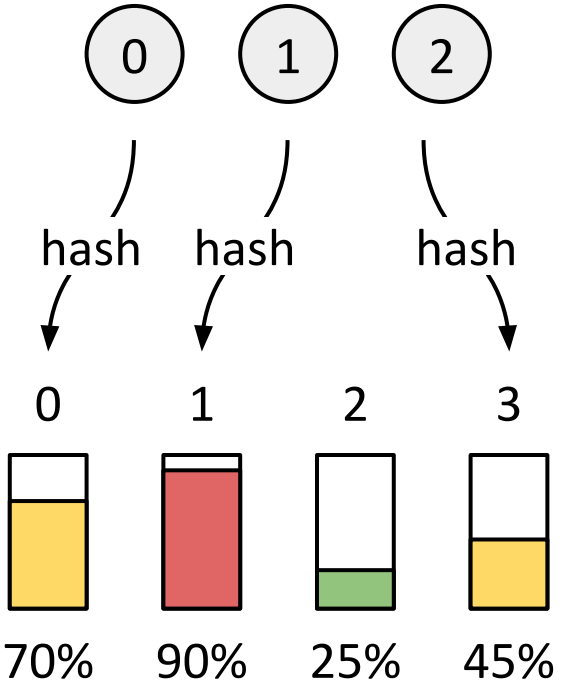

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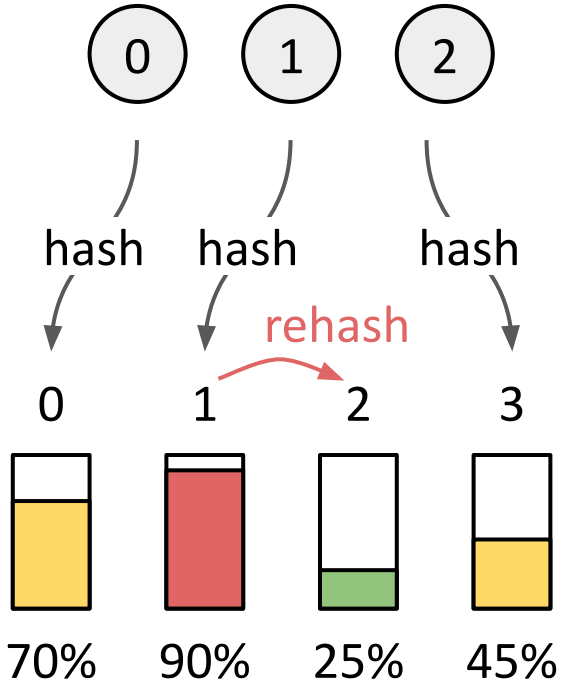

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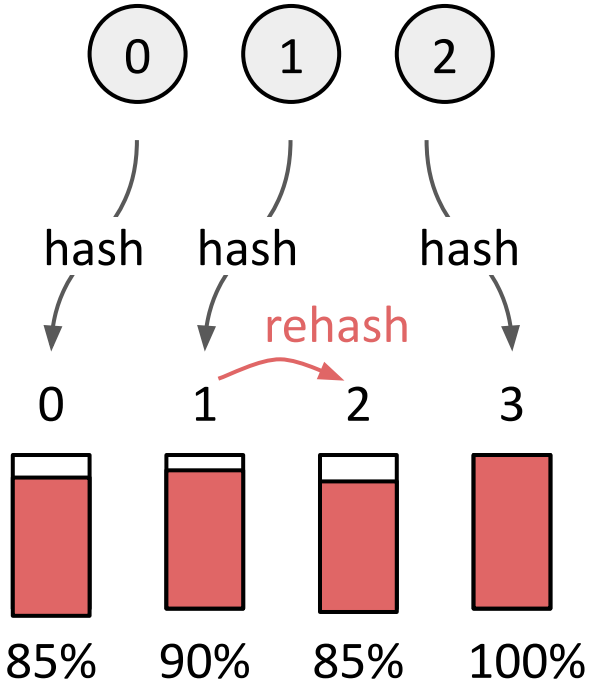

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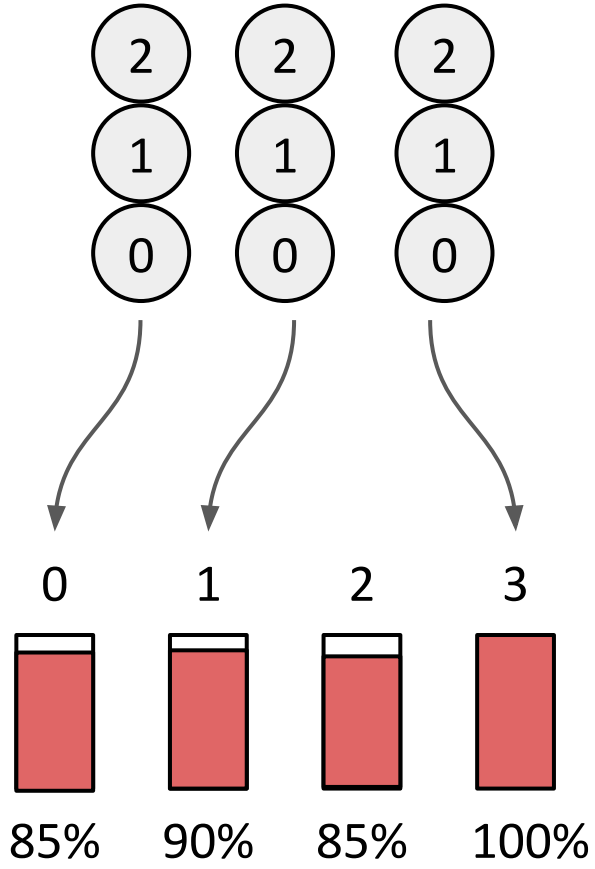
- When whole system is overloaded, FALCON can be dynamically disabled.



Evaluation - Setup

Hardware: Intel 40 logical cores @ 2.2GHz, 128 GB RAM
NIC: Mellanox ConnectX-5 EN (100 Gbps)
Software: Ubuntu 18.04 with Linux kernel v5.4

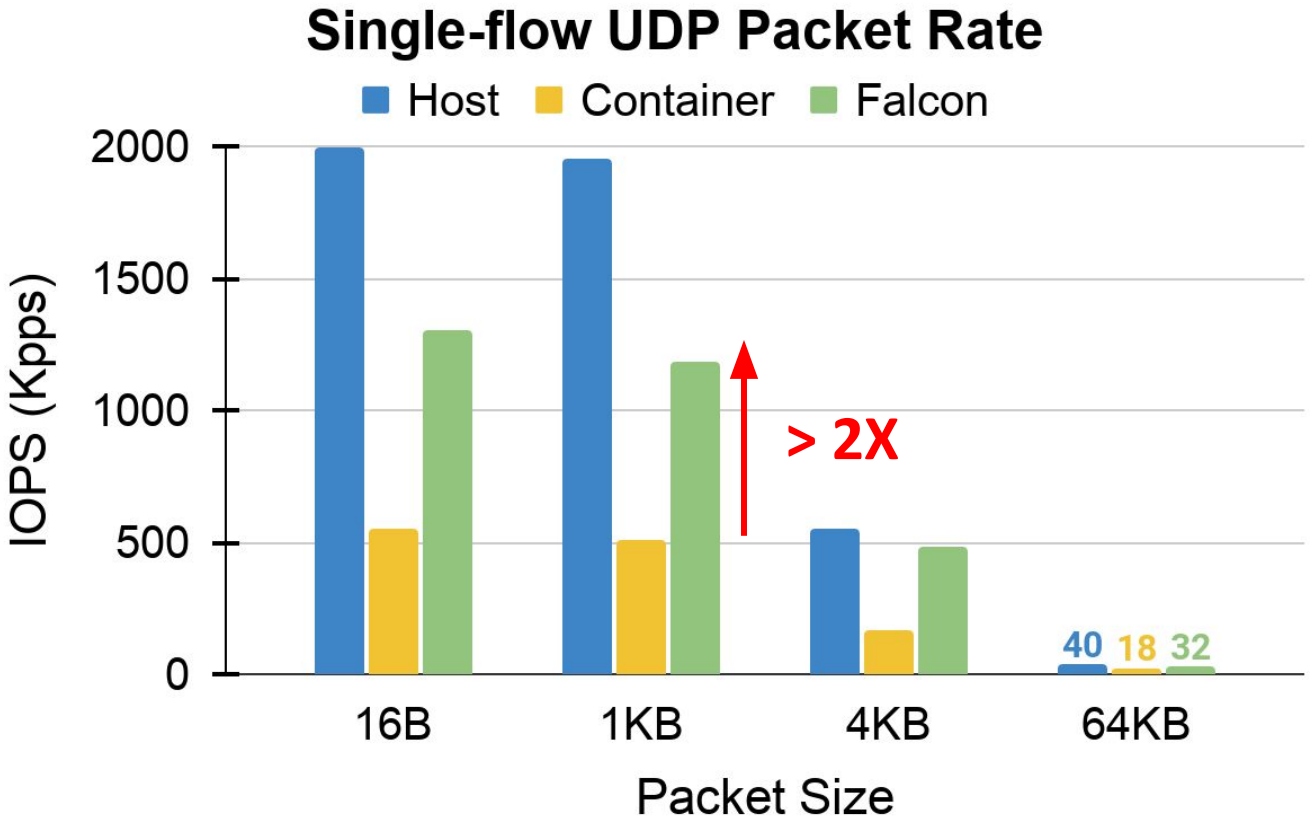
Performance comparisons: Host vs. Container vs. FALCON

Experiments:

- Single-flow and multi-flow microbenchmarks
- Load balancing
- Cloudsuite benchmark (memcached)

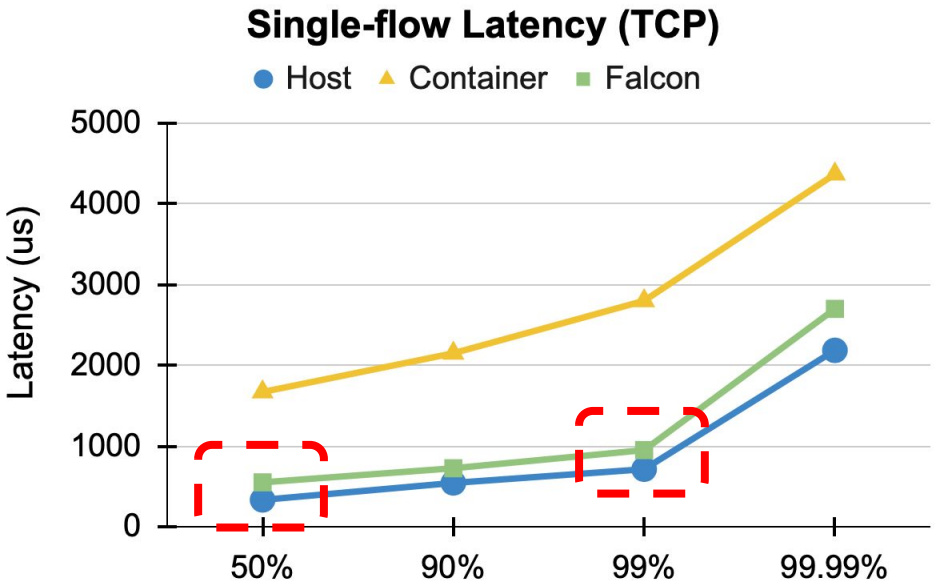
Single-flow Performance

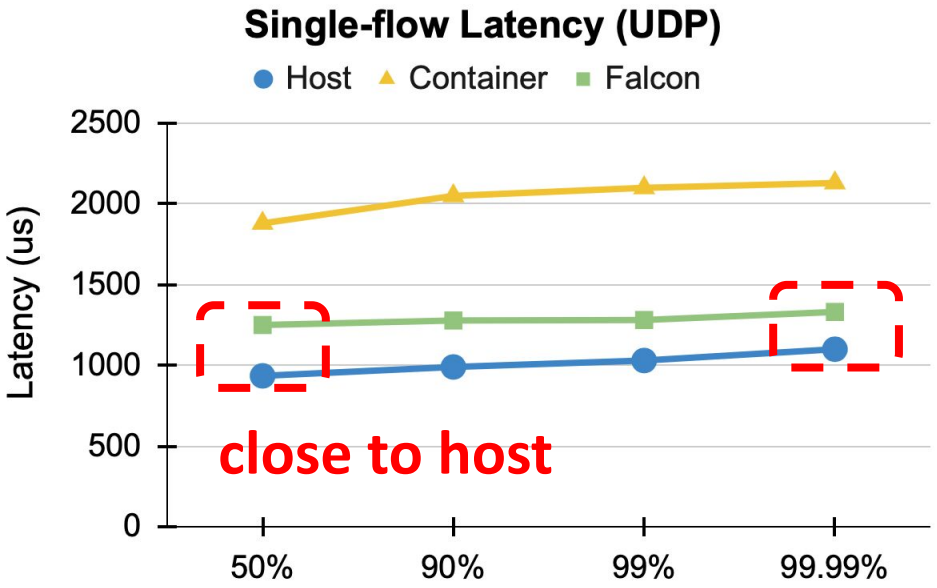
- More than **2X** improvement than vanilla container



Single-flow Performance

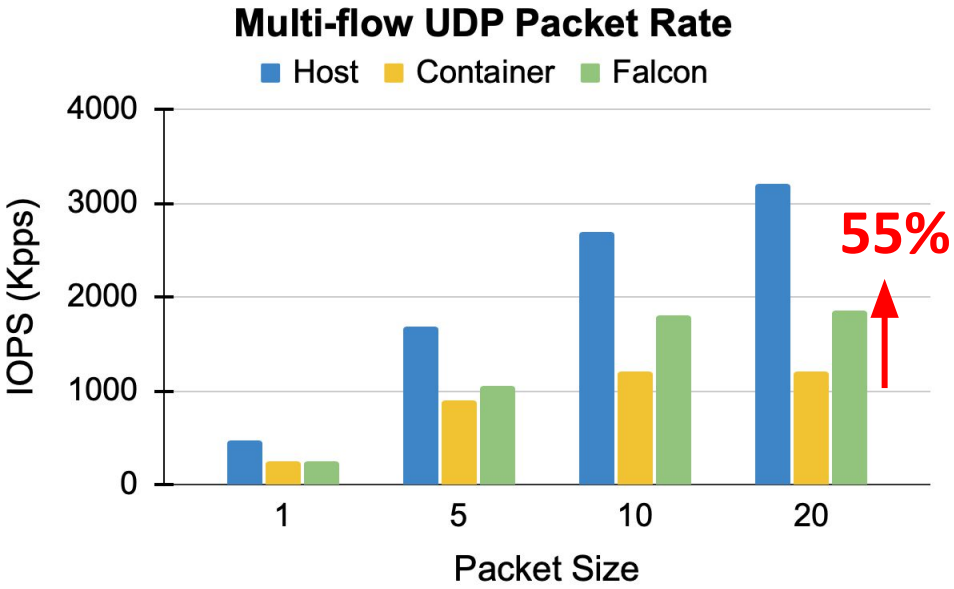
- Both median and tail latency get **close to host** networks.

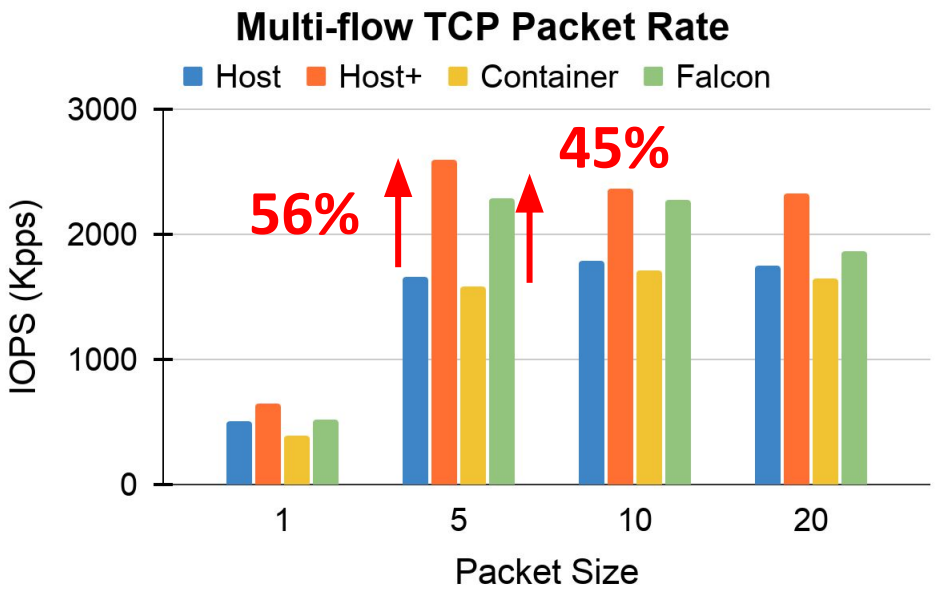




Multi-flow Performance

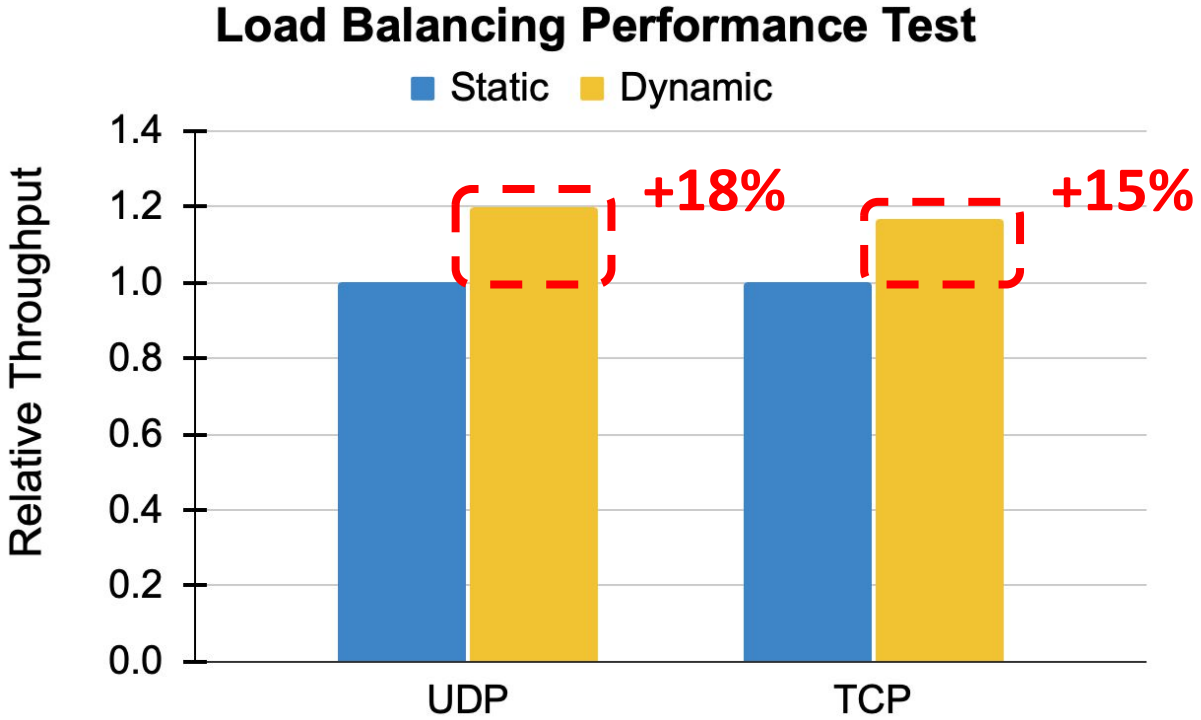
- UDP: as much as **55%** improvement
- TCP: improve host network by **56%**, overlay network by **45%**





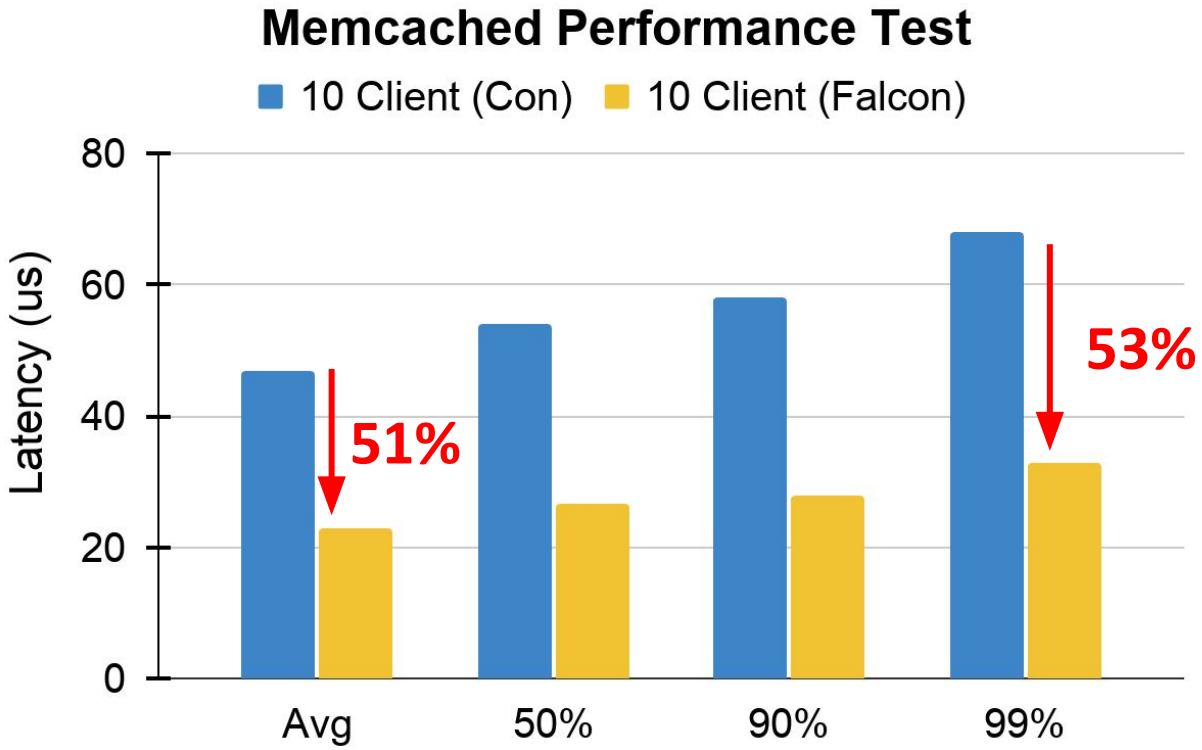
Load Balancing

- Increase the intensity of certain flows suddenly
- Improvement: UDP - **18%** ; TCP - **15%**



Memcached Performance

- With 10 clients, Falcon reduces the average and tail latency by **51%** and **53%**



Conclusions

- Excessive, serialized and expensive SoftIRQs incur significant performance loss for overlay networks.
- FALCON parallelizes the SoftIRQs processing by utilizing the multicore architecture.
- FALCON can significantly improve the performance of container overlay networks.
- Our implementation is open-sourced at: github.com/munikarmanish/falcon

Thank you!