Making Serverless Computing More Serverless

Zaid Al-Ali, Sepideh Goodarzy, Ethan Hunter, Sangtae Ha, Richard Han, Eric Keller
University of Colorado Boulder

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IBM Research

University of Colorado Boulder

IBM Research

Serverless Background

- Serverless offerings are widespread today

Amazon Lambda

Google Cloud Functions

IBM Cloud Functions

Azure Functions

Apache OpenWhisk

OpenFaaS

fission

Dispatch

Today’s serverless abstraction

- Serverless typically means Function-as-a-Service

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Benefits
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Simple scale-out support
Low cost

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Benefits	Shortcomings
No need to manage infrastructure	Event-driven frameworks only
Simple scale-out support	Stateless
Low cost	Function instance bound to server

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This talk: propose new serverless abstraction and overview its design

Today's serverless abstraction

Making Serverless Computing More Serverless

FaaS, Lamda, OpenWhisk, …

Break limitations of single server

Zaid Al-Ali†, Sepideh Goodarzy†, Ethan Hunter†, Sangtae Ha†, Richard Han†, Eric Keller†, Eric Rozner*
†University of Colorado Boulder; *IBM Research

***Abstract*—In serverless computing, developers define a function to handle an event, and the serverless framework horizontally scales the application as needed. The downside of this function-based abstraction is it limits the type of application supported and places a bound on the function to be within the physical resource limitations of the server the function executes on. In this paper we propose a new abstraction**

through memory or storage. The challenge, of course, is realizing a process-based serverless framework which can map our serverless process abstraction to an underlying, physically distributed infrastructure. To that end, we propose a new architecture called ServerlessOS to enable our vision and argue three key components are necessary to make our

Low cost

Function instance bound to server

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A new serverless abstraction

- Expand serverless beyond the bounds of FaaS
- Goals of our new abstraction:

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Flexible enough to support general set of applications

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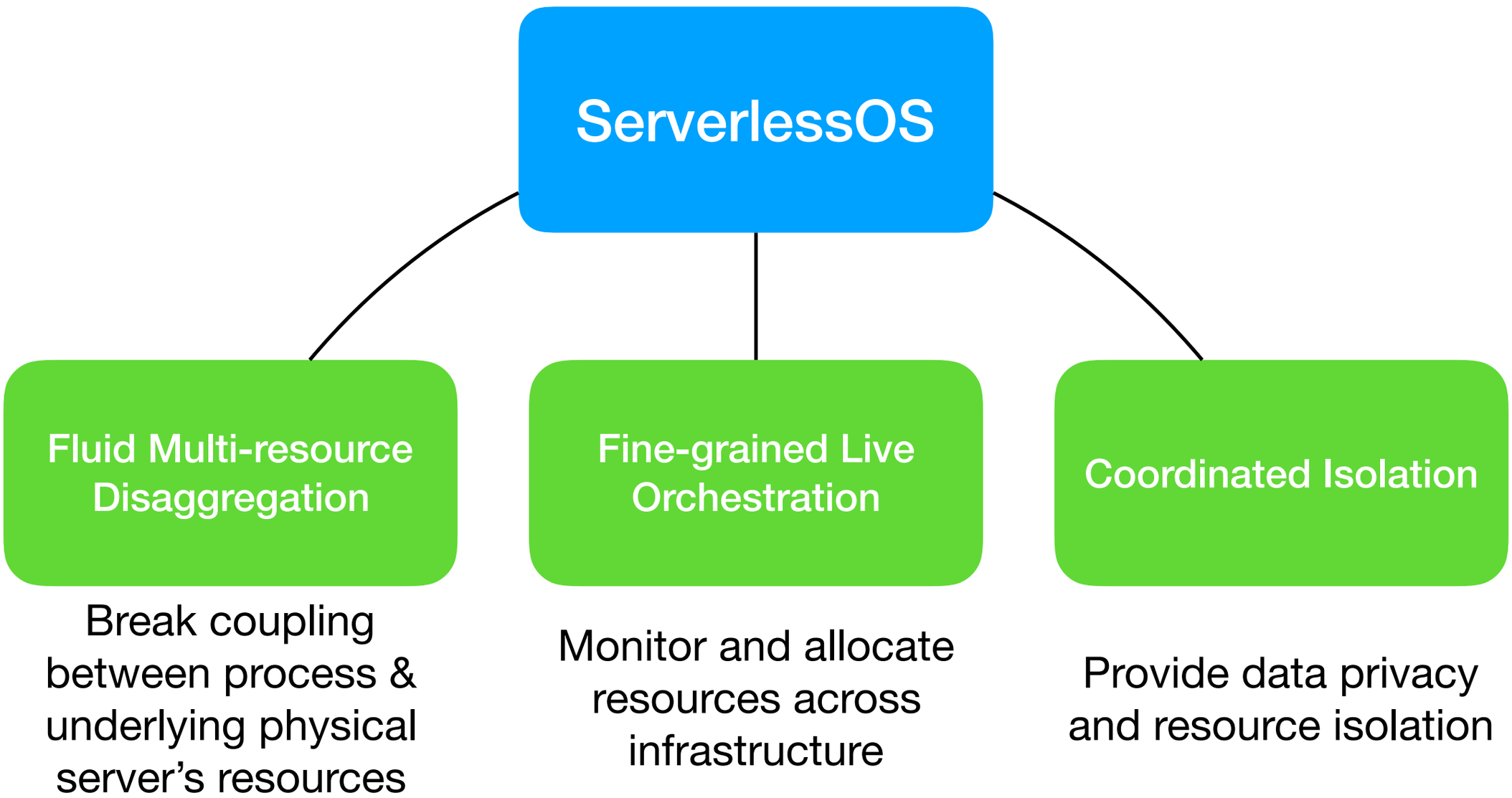
Challenge: map serverless process abstraction to underlying physically distributed architecture

Outline of talk

- Goal: provide seamless, scale-out process abstraction
- This talk: high-level outline of our *ServerlessOS* vision



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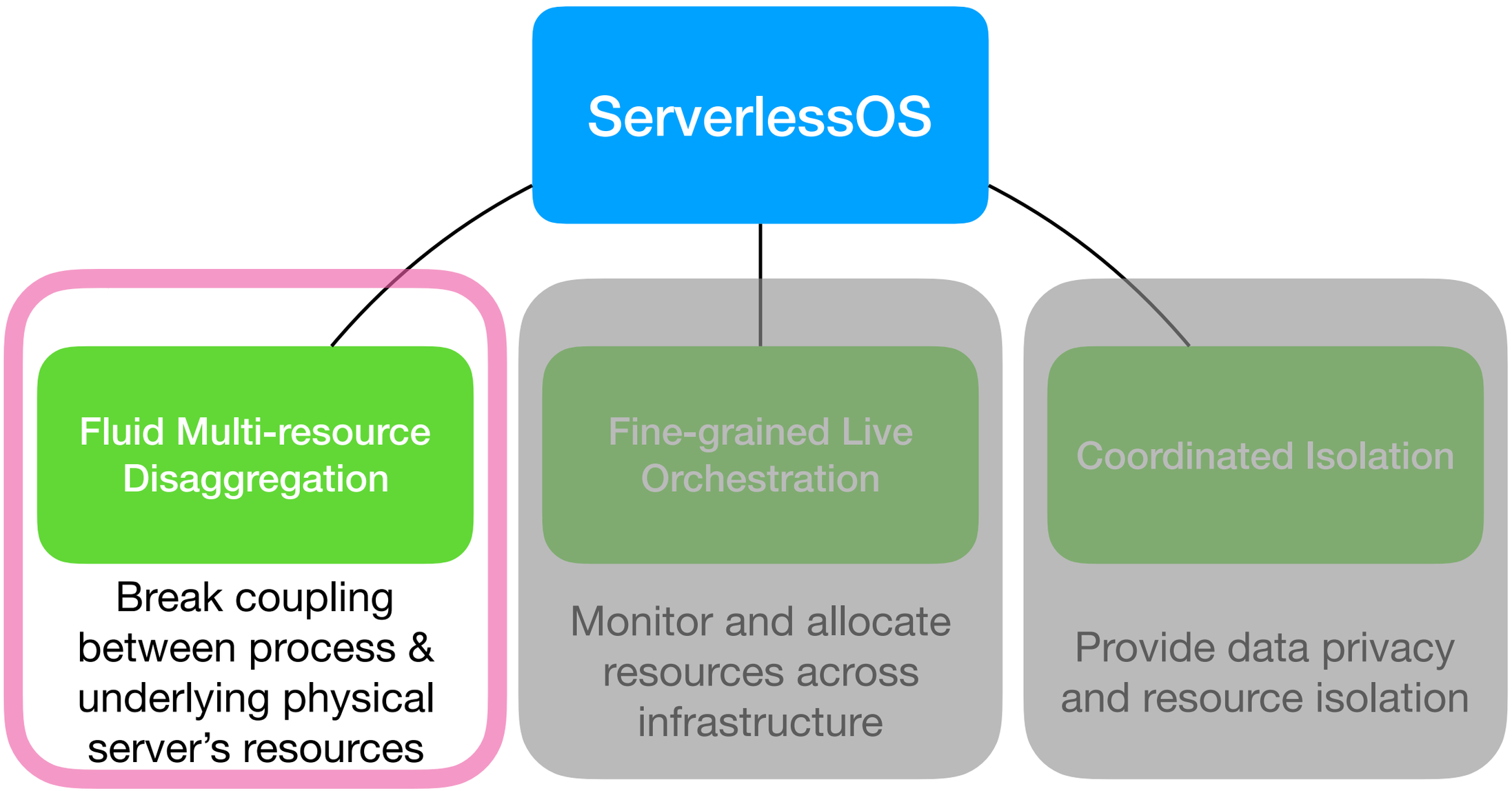
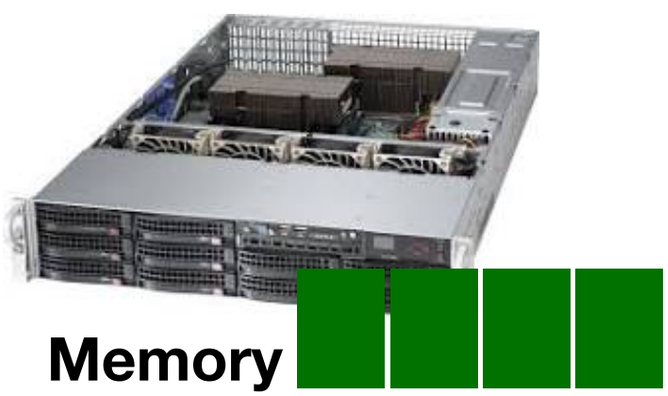
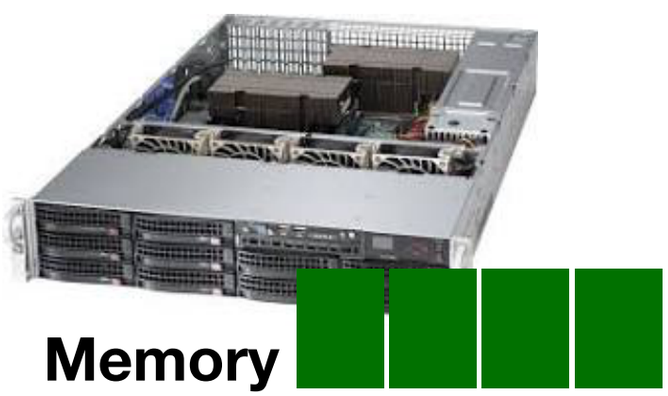


Fluid multi-resource disaggregation

- Break coupling between process & underlying physical server resources

Fluid multi-resource disaggregation





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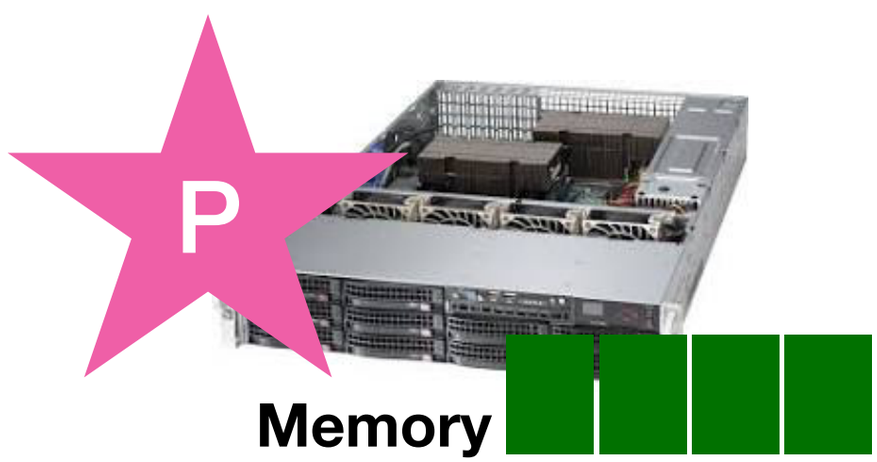

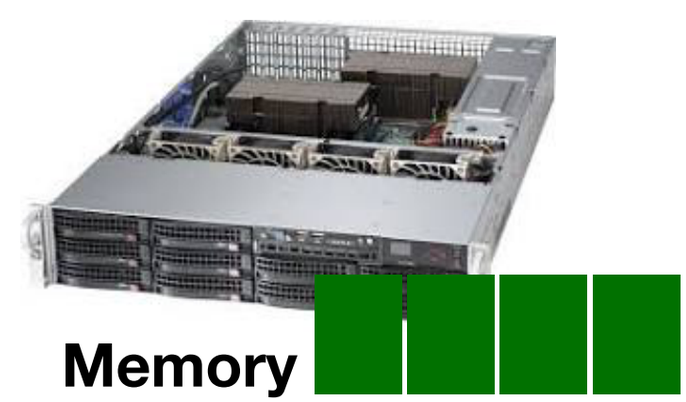

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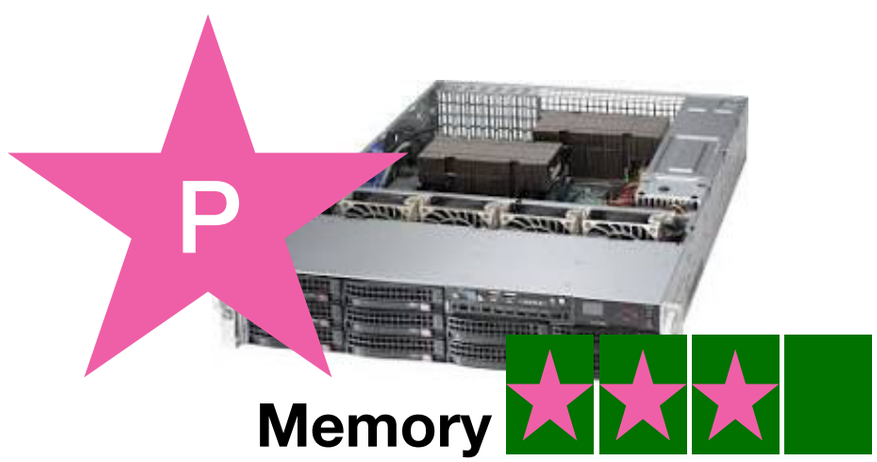

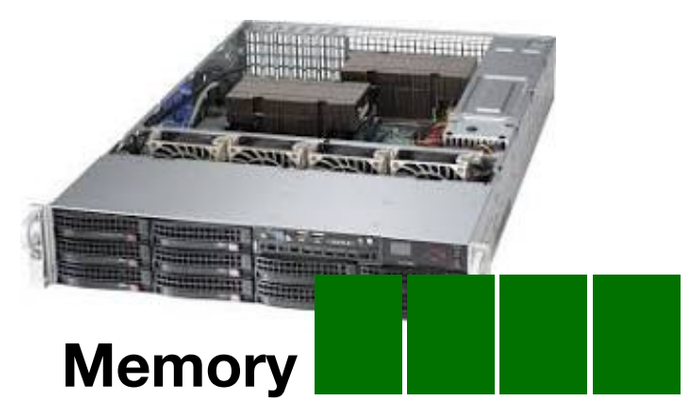

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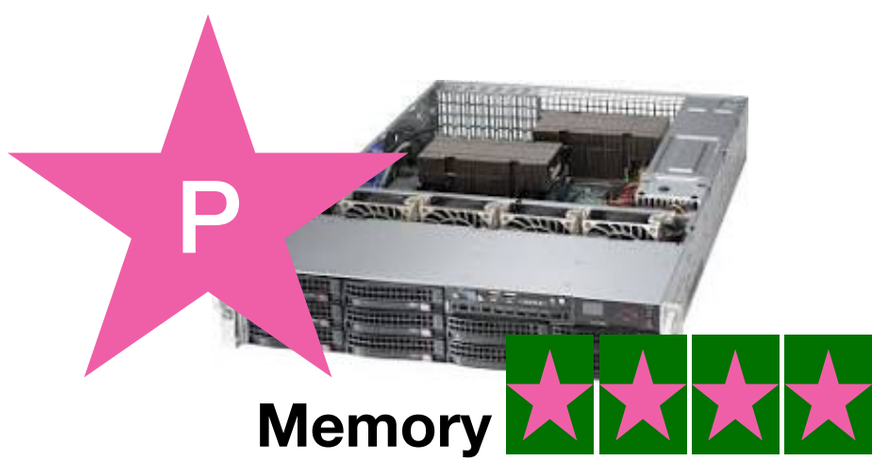

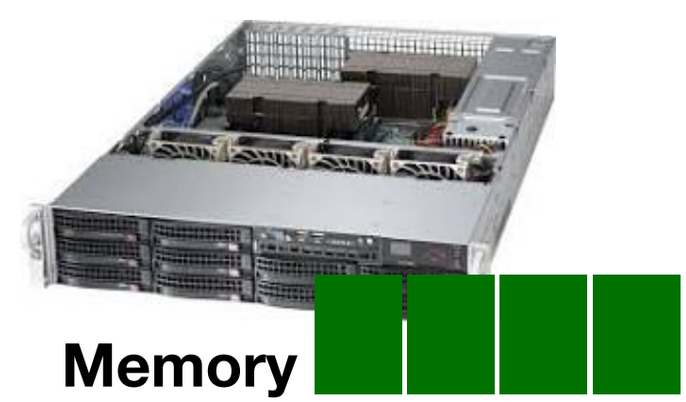

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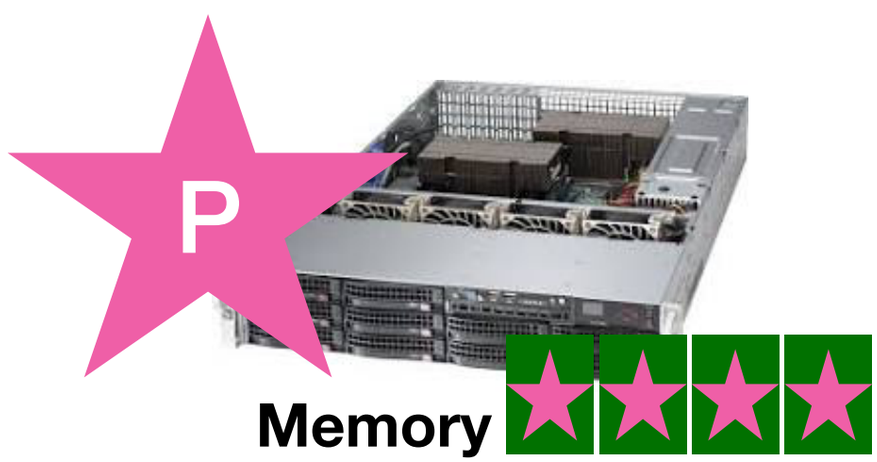
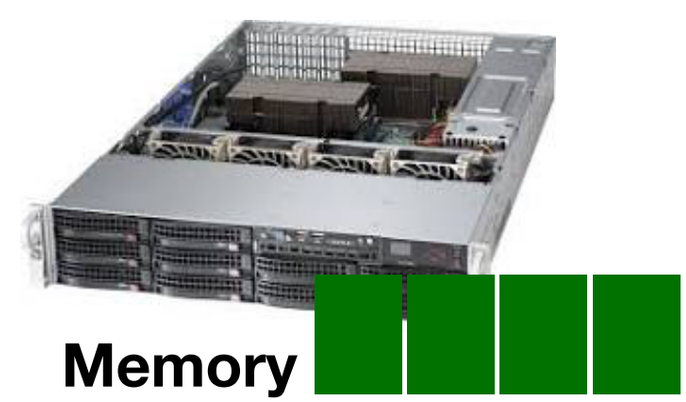


Expand memory footprint



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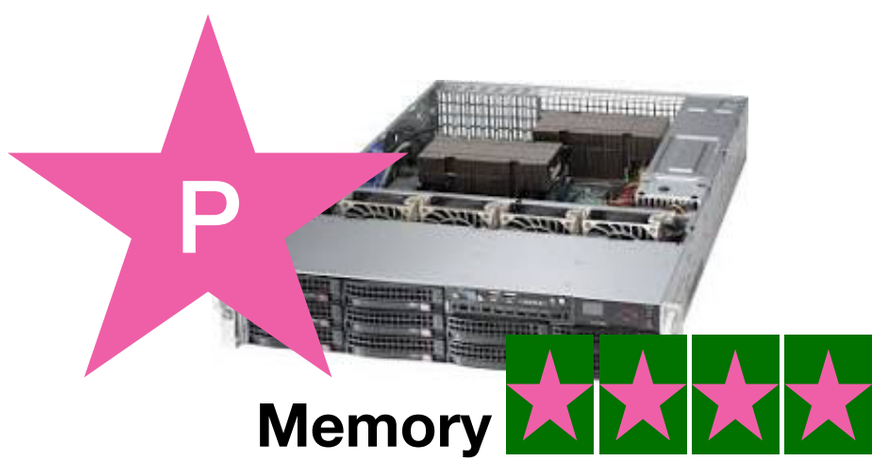

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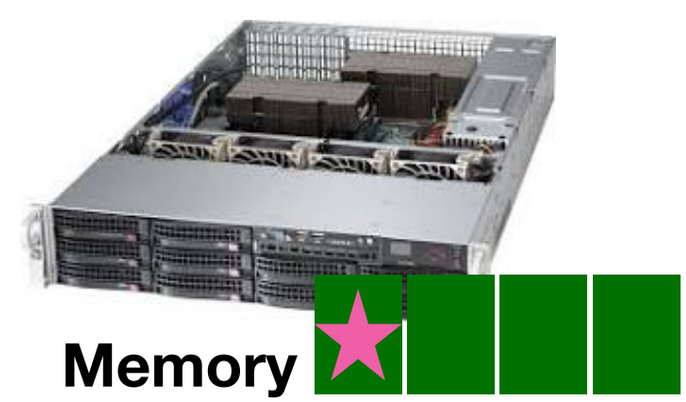

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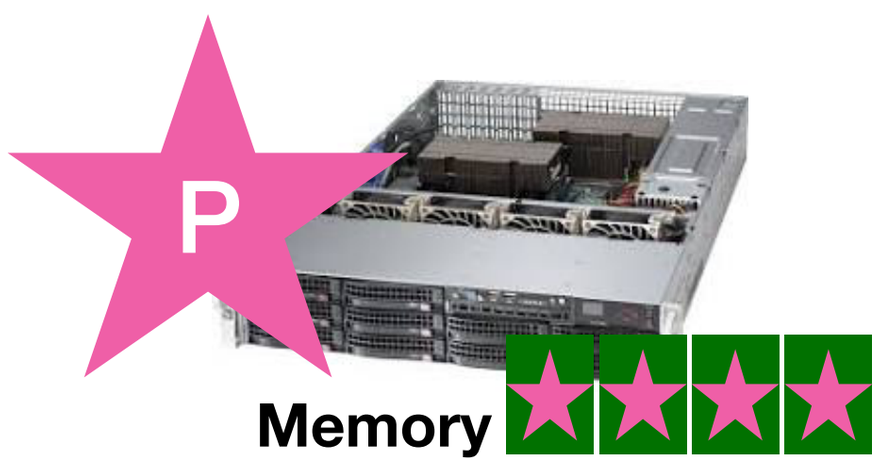

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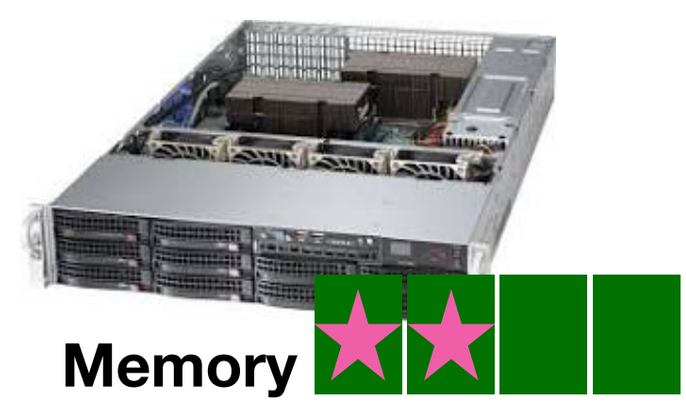

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Disaggregation: decouple process's resources from single server

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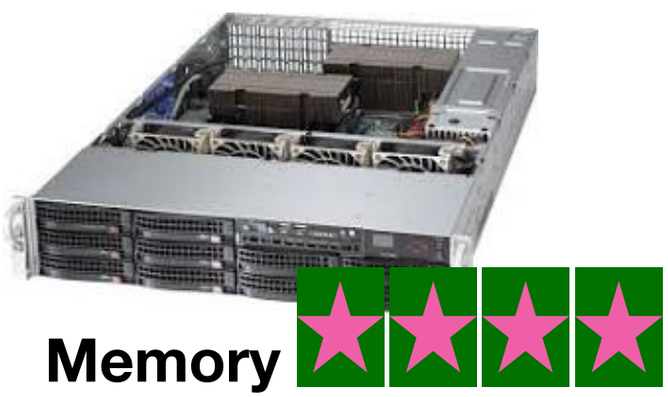

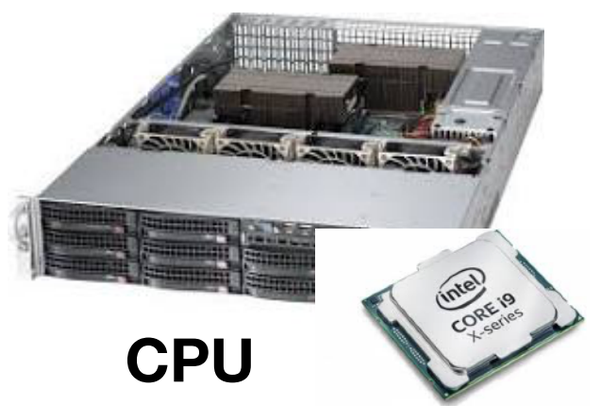

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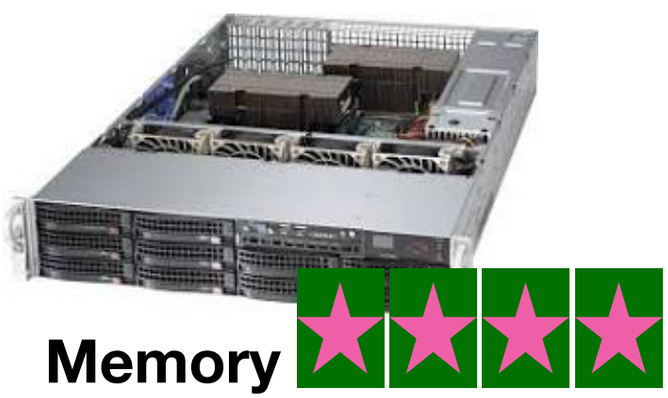

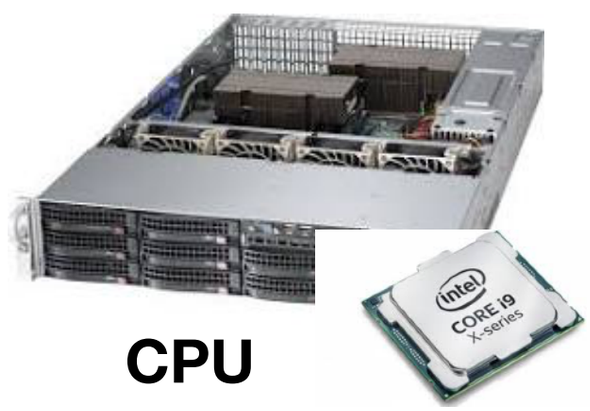

Decouple memory, compute, I/O to increase flexibility

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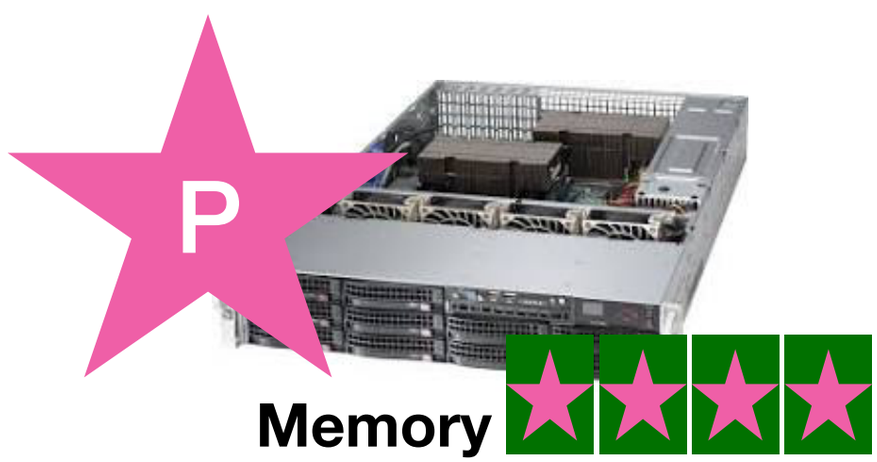

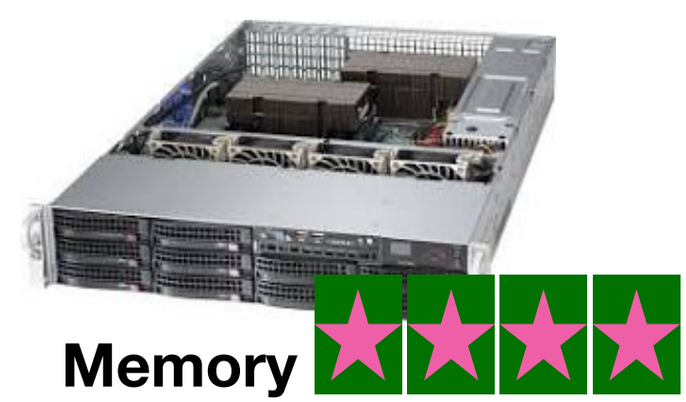

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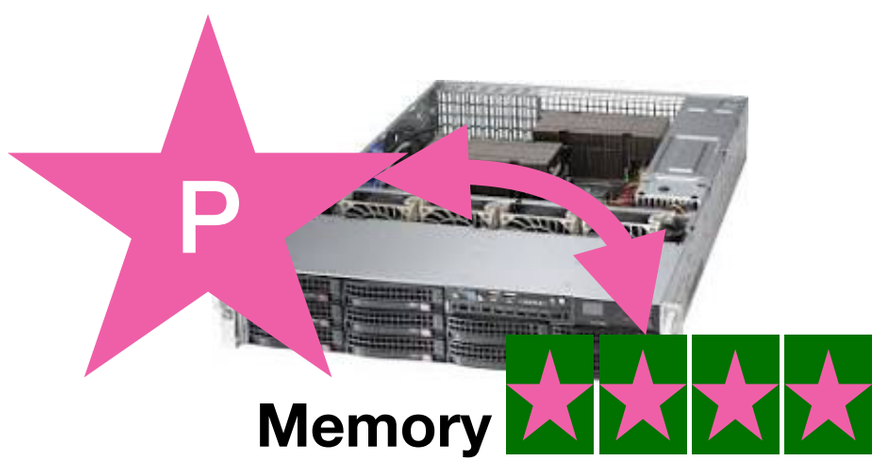

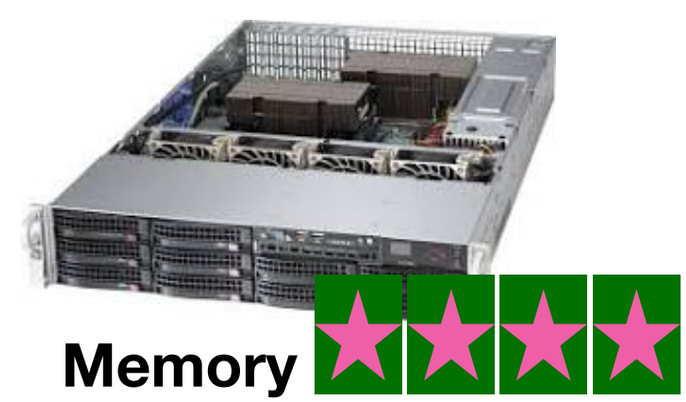

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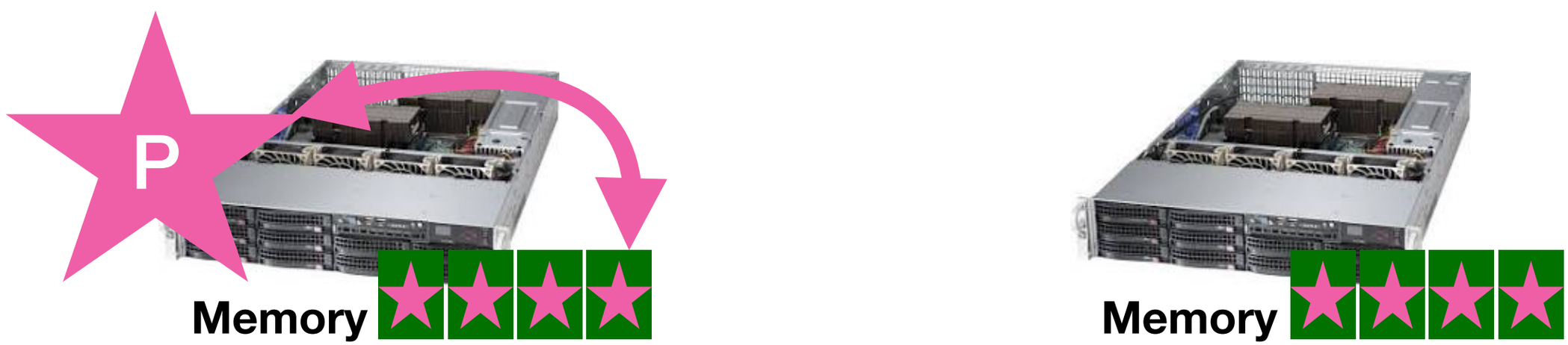

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Acessing remote memory incurs much higher overhead than local memory

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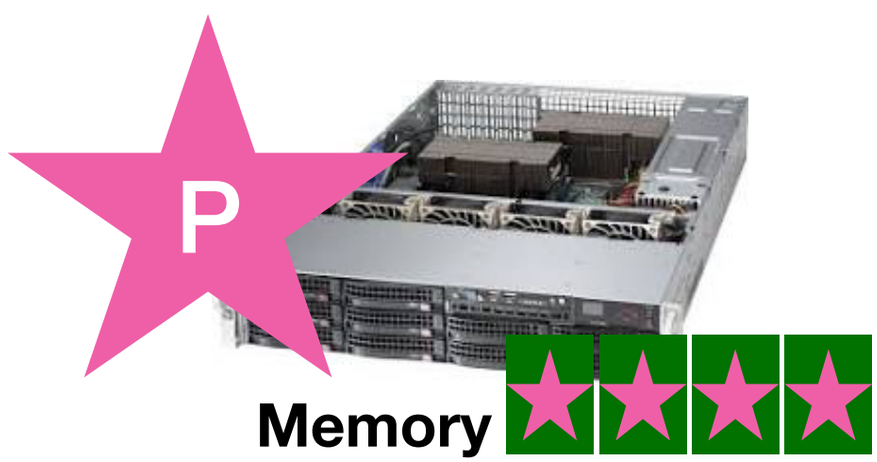

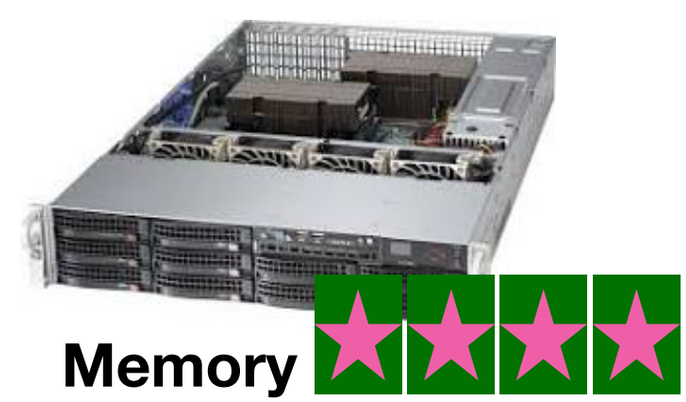

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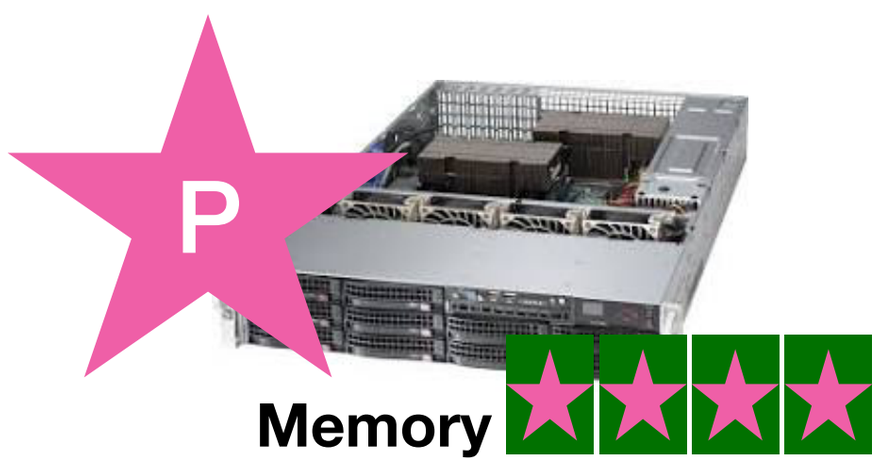

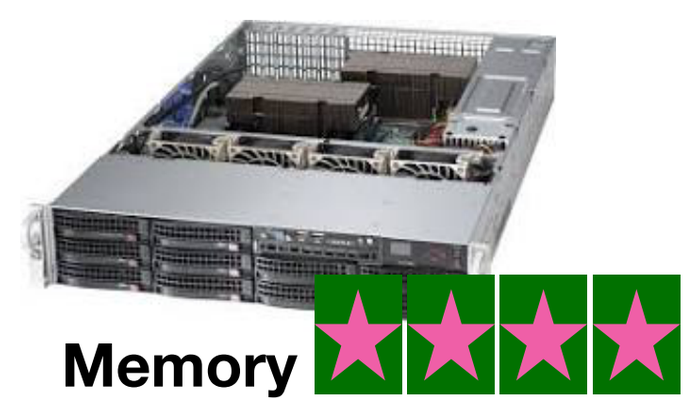

Fluidity: allow process to *move to* data when more efficient

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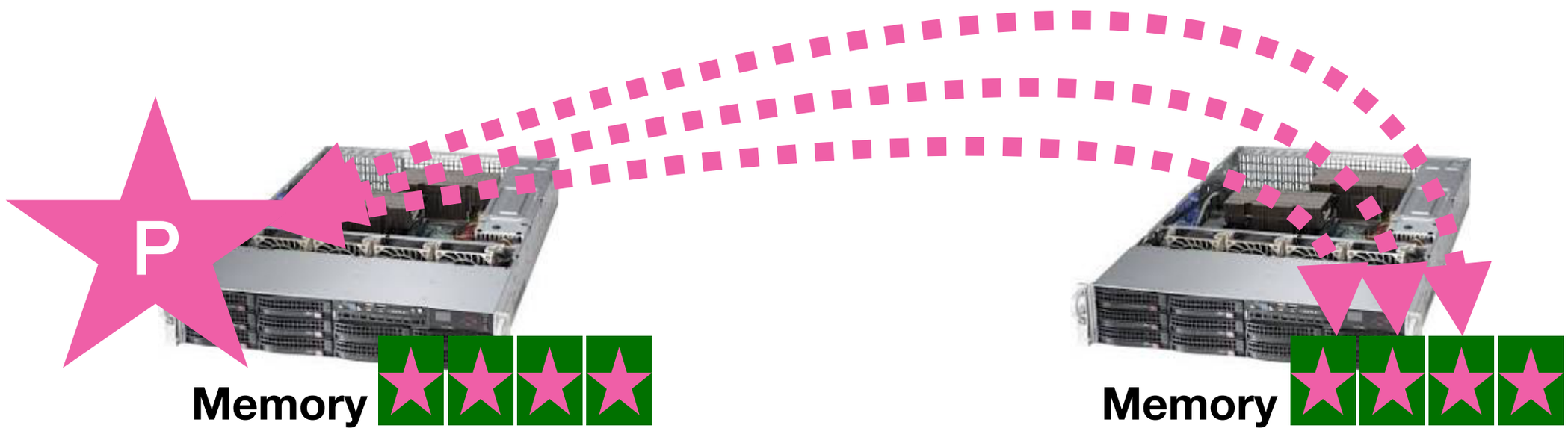

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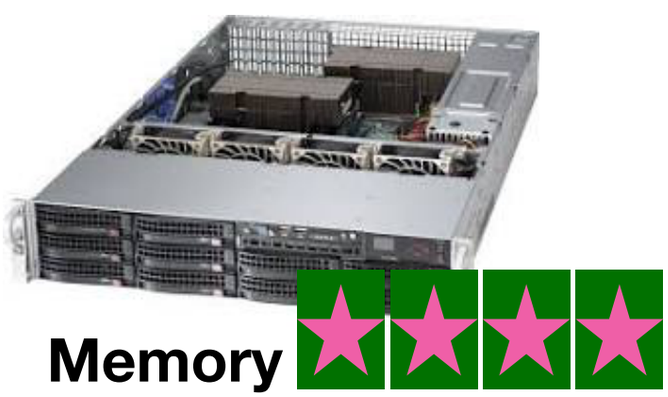

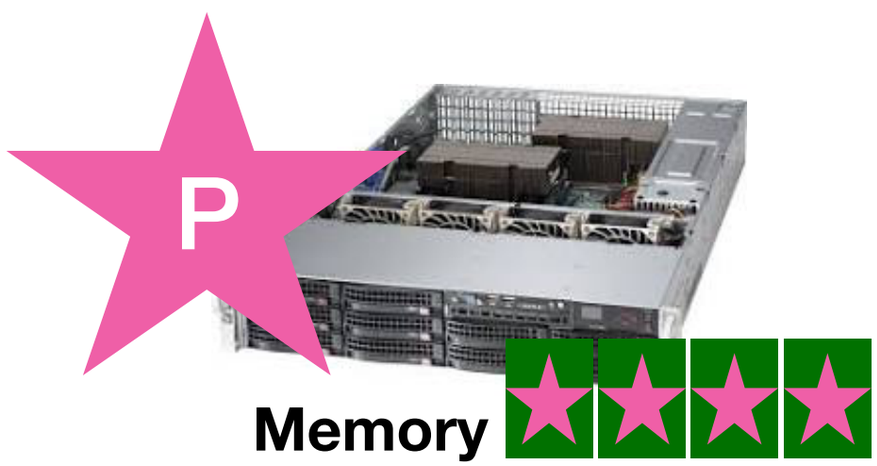

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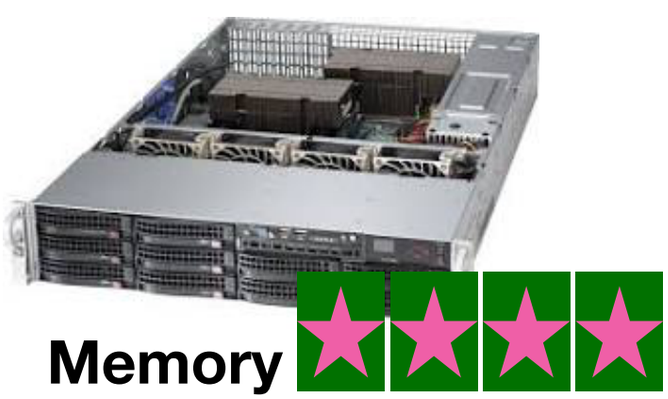
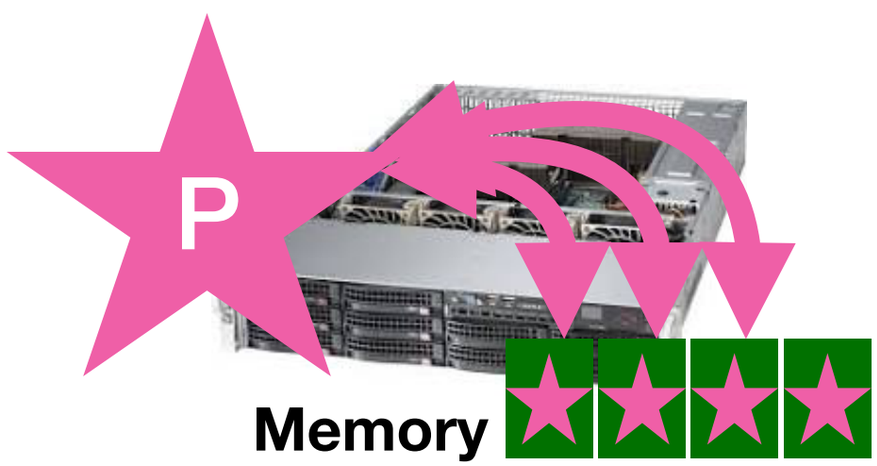
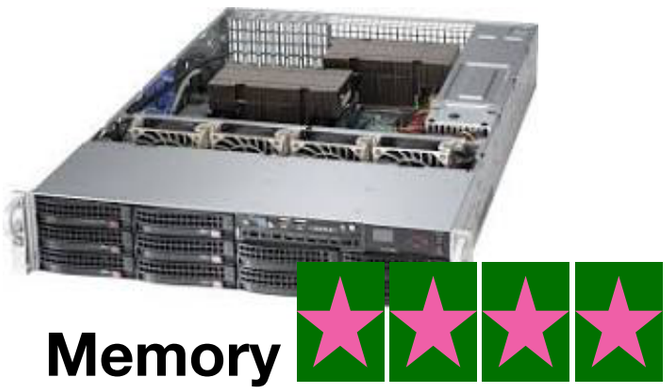


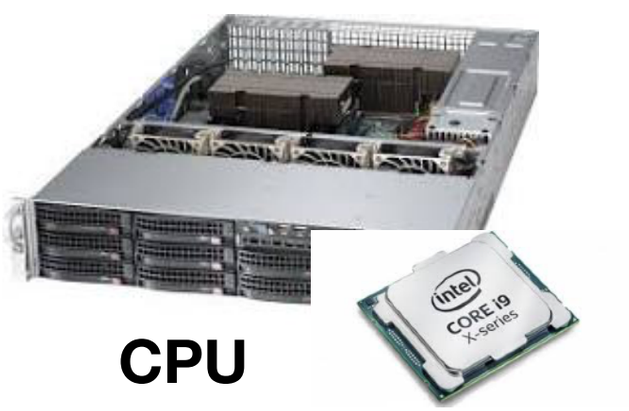


Fluidity: enable process to exploit locality to improve performance

Fluidity over multiple resources



Already provided by prior works
(RamCloud, DSM, InfiniSwap, …)



Move processing to data or other
server with more compute resources
(Initial results show 2-3x speedup over a DSM scheme)

Decouple device that captured I/O from device that will process I/O. Additionally, move I/O to more bandwidth.
(CPU fluidity can move processing with socket)

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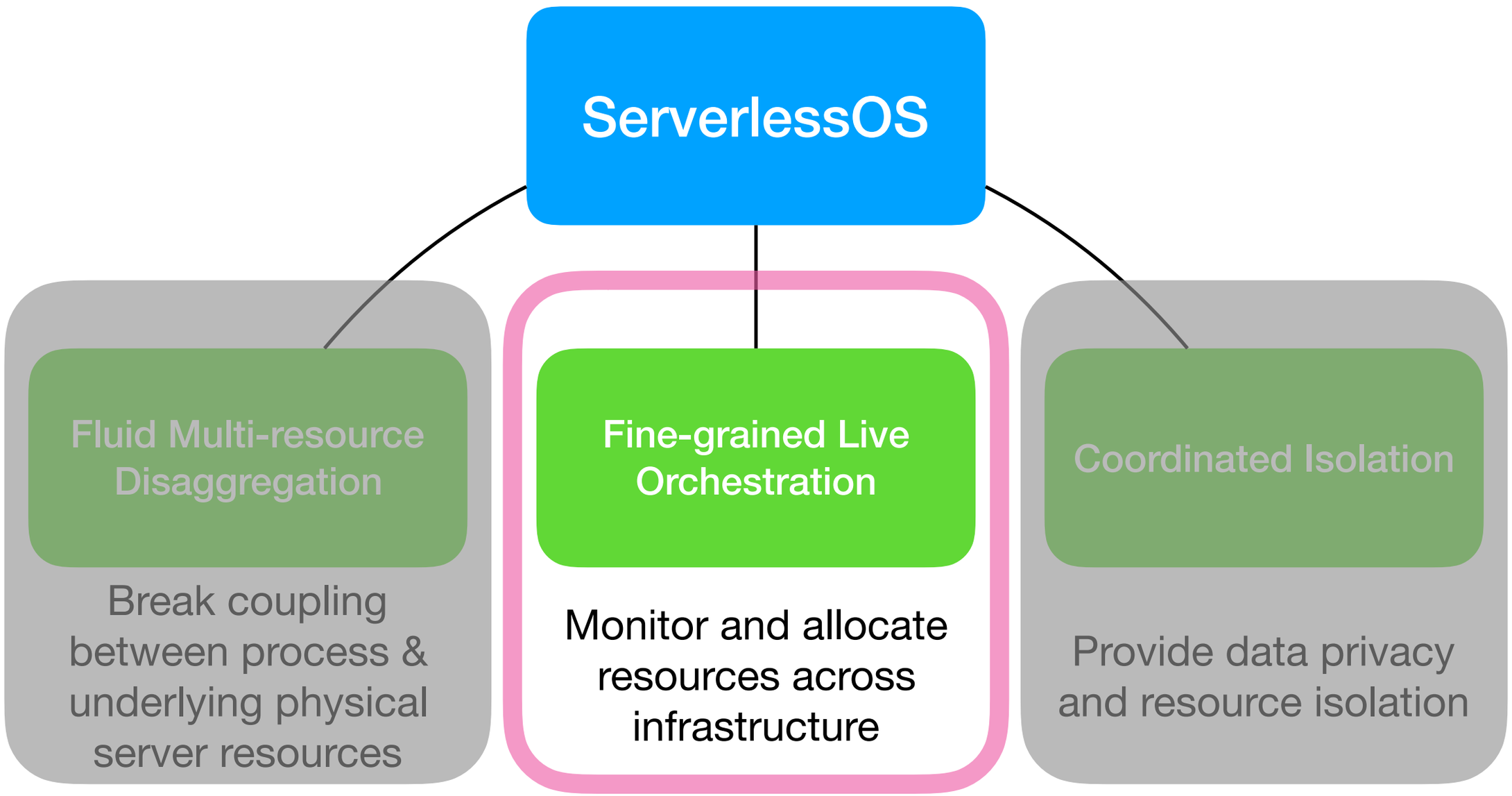

Fine-grained live orchestration layer

- Monitor, allocate, and optimize run-time performance by automatically assigning, migrating, or scaling workloads

Global decision making

Fine-grained live orchestration layer

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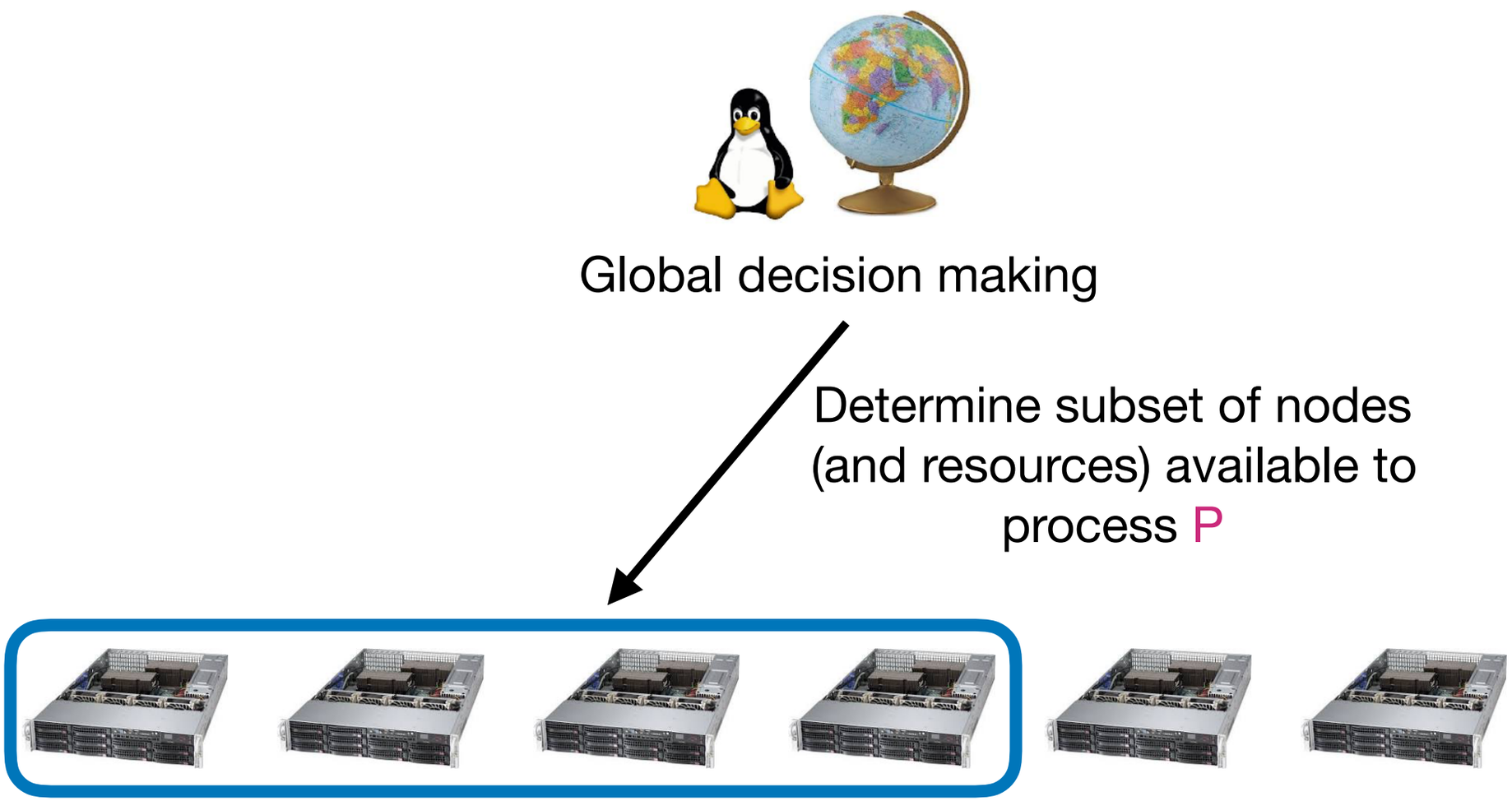

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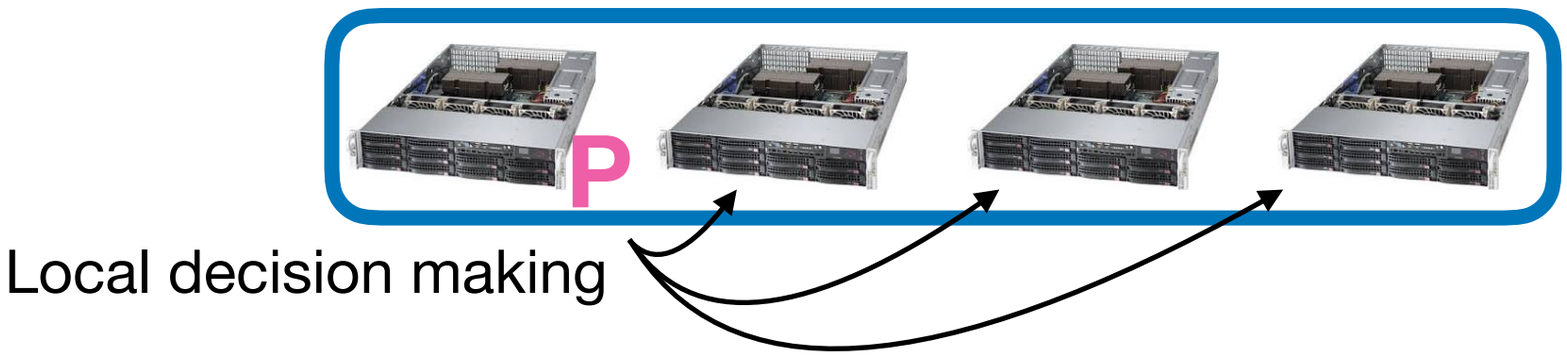

- When to expand (or contract)
- Where to expand (or contract)

Both decisions influenced by state of other local nodes:

- CPU
- Memory
- Network

Backpressure algorithm avoids poor decisions

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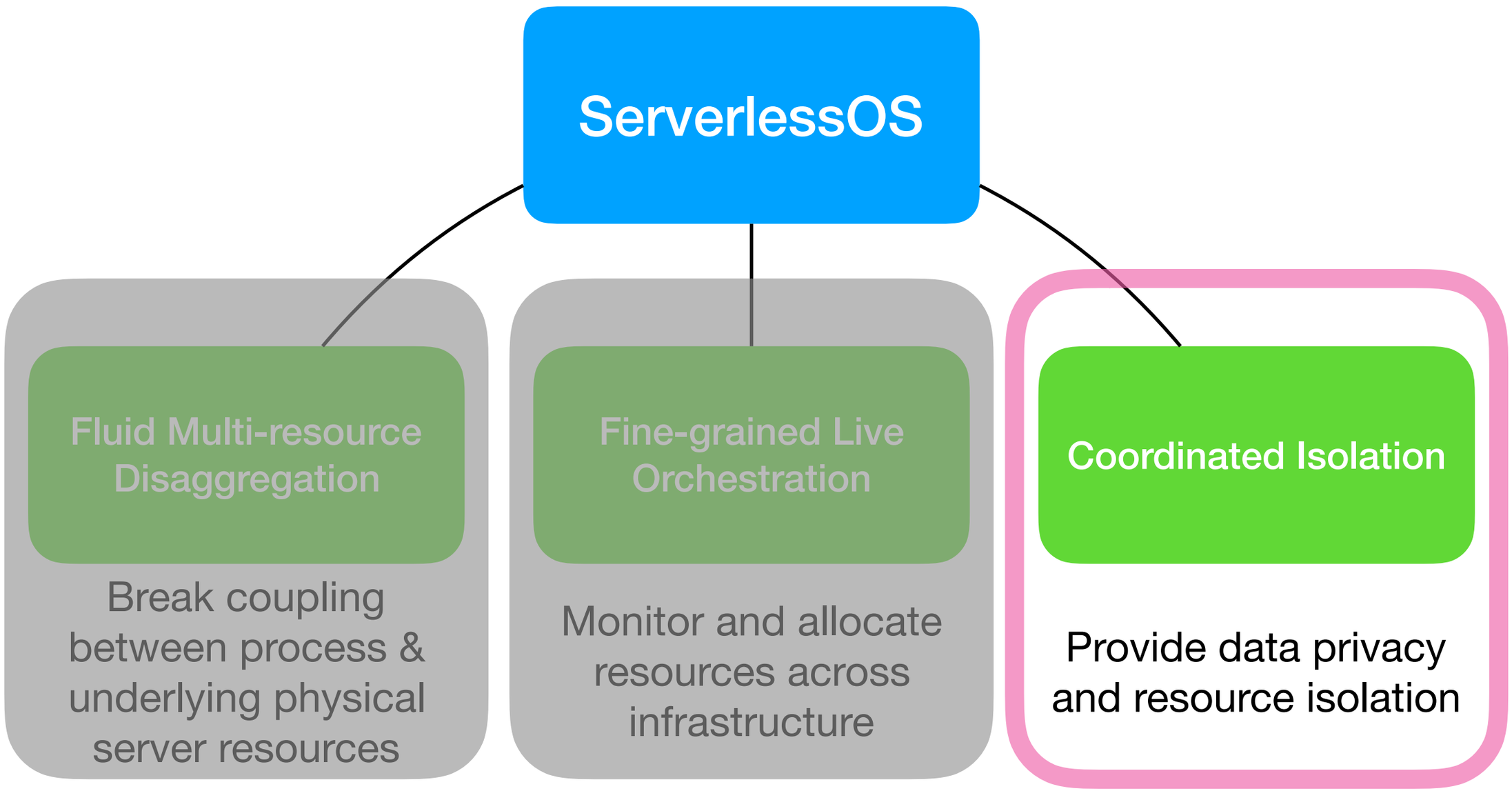

Coordinated Isolation

Data Privacy

Ensure application cannot read or write state from another application

Resource Isolation

Bound CPU, memory, storage, and network usage of workloads

Coordinated Isolation

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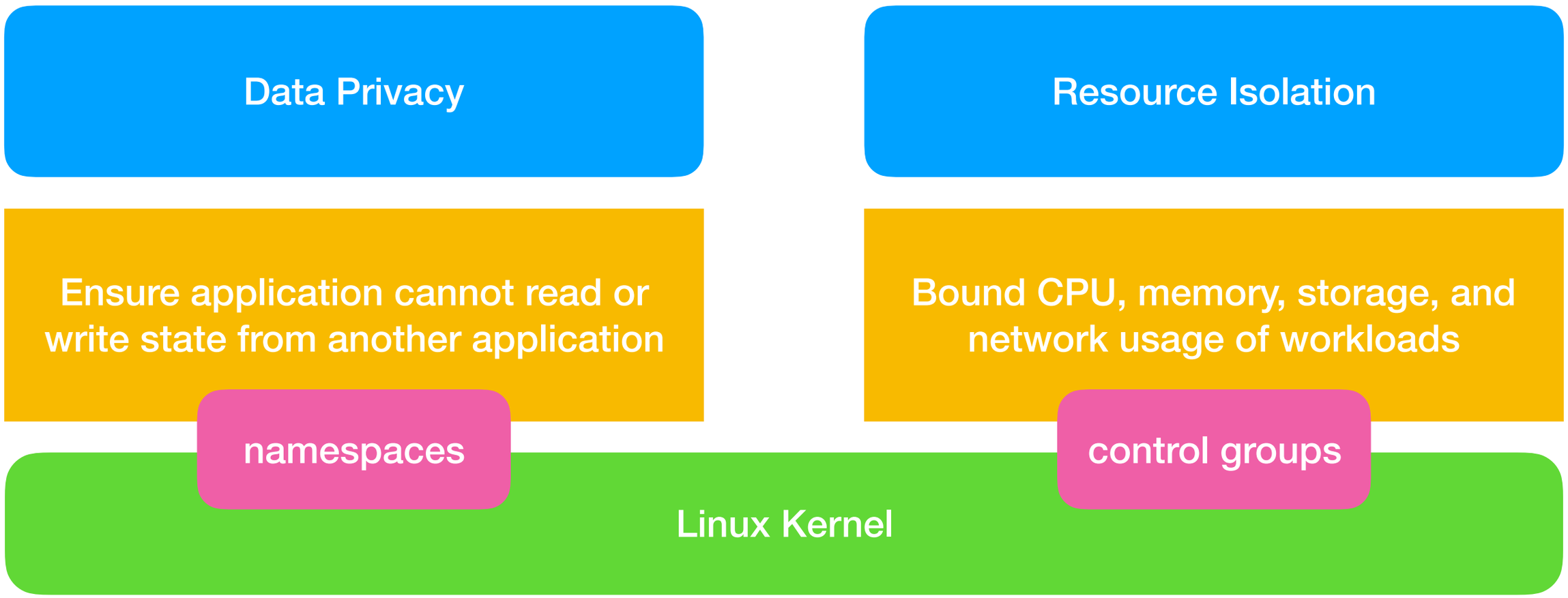
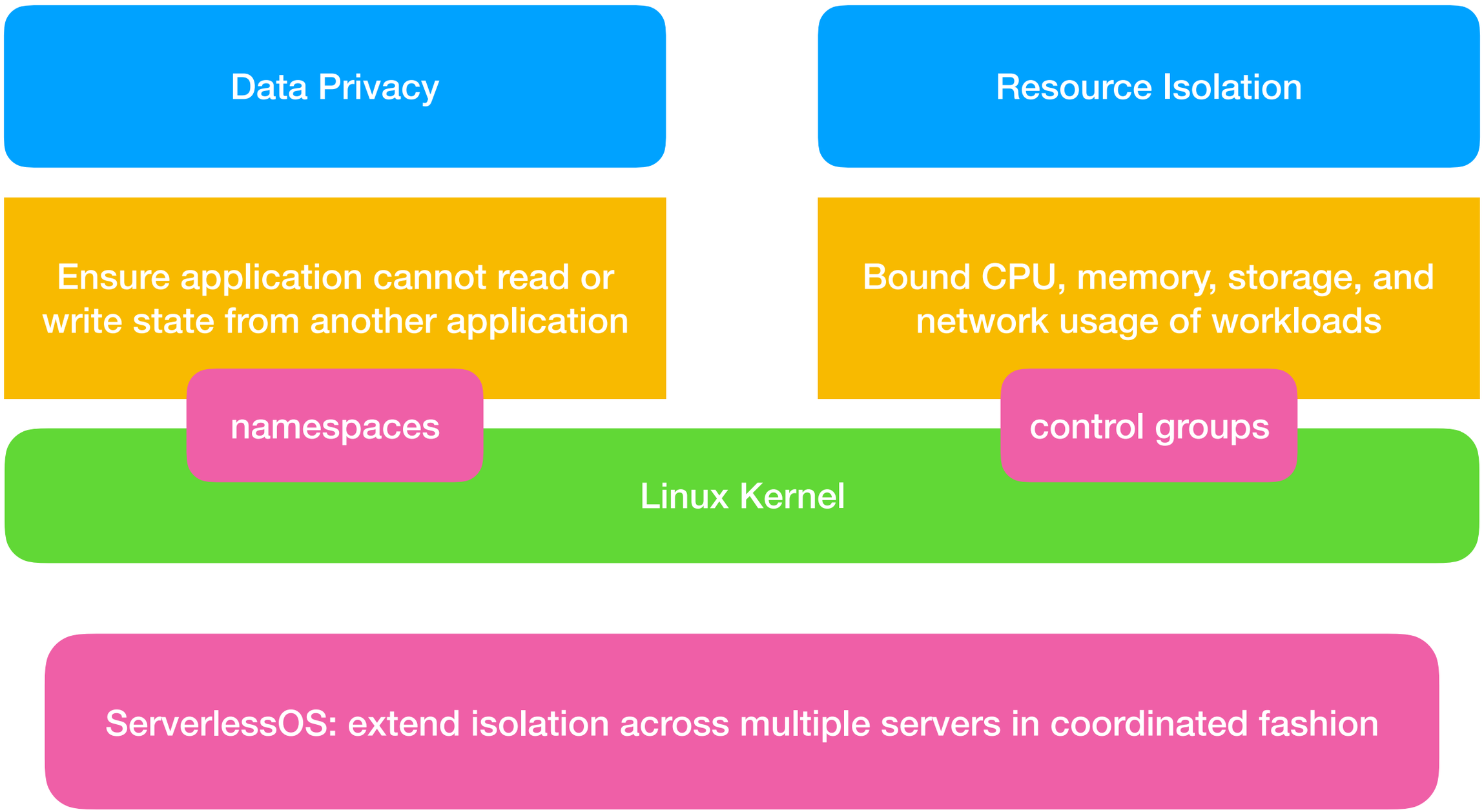
Linux Kernel

Coordinated Isolation



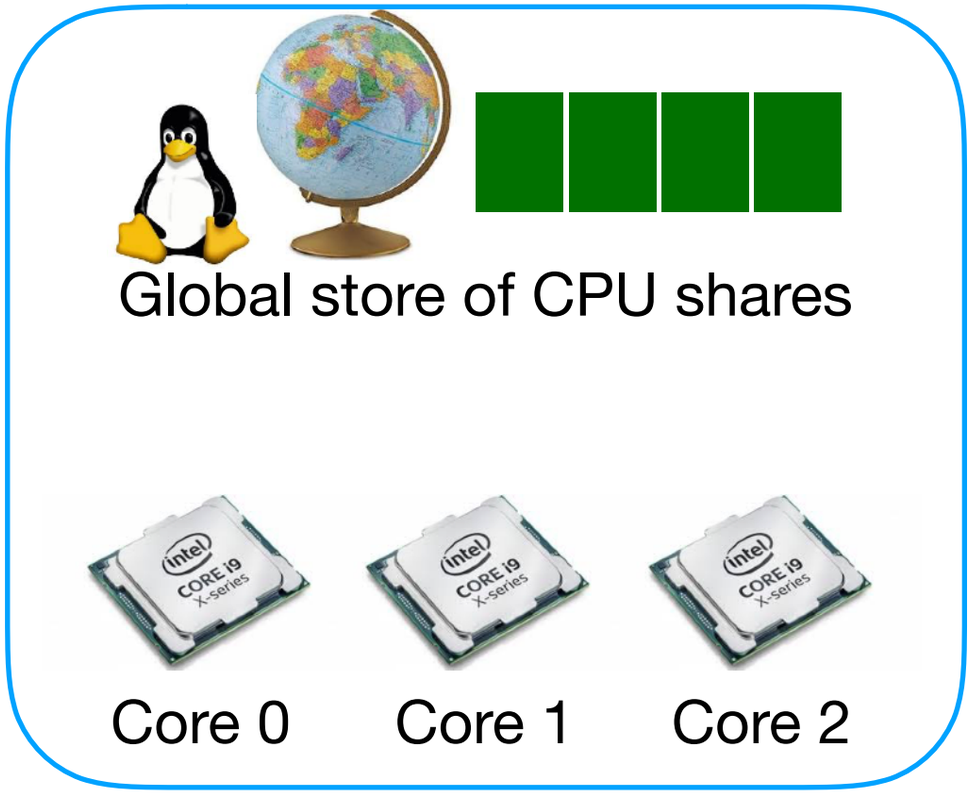
Coordinated Isolation



Coordinated Isolation

namespaces — Extend process namespace across multiple servers

control groups — Centralize state in orchestration layer, but minimize overheads



From single server…

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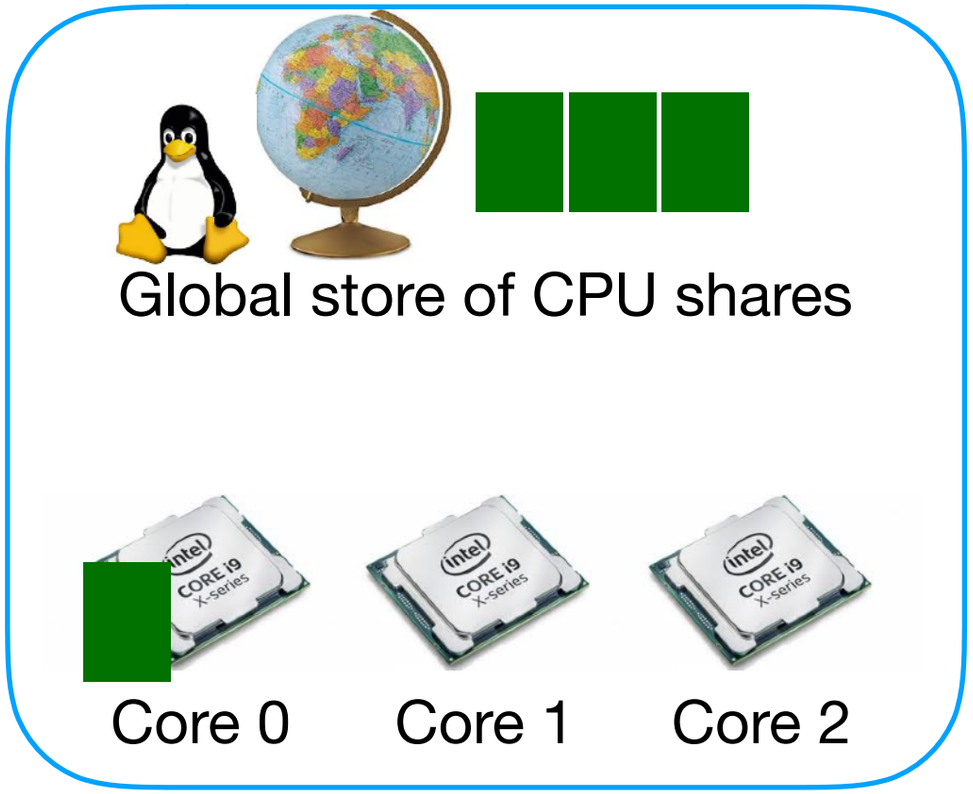

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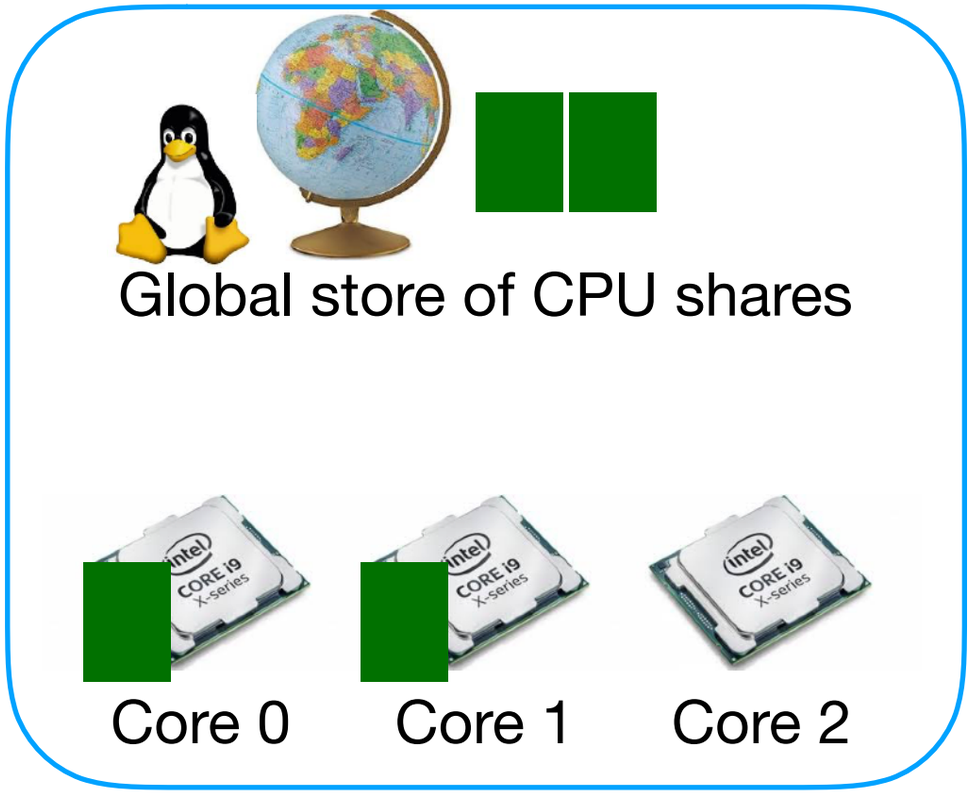

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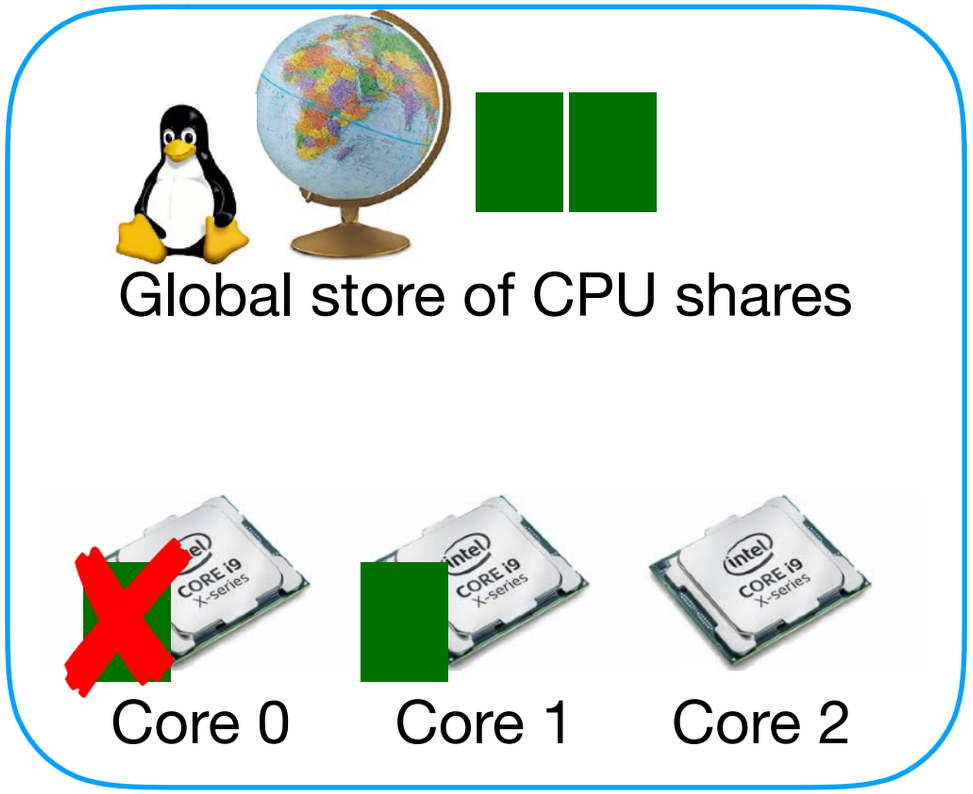

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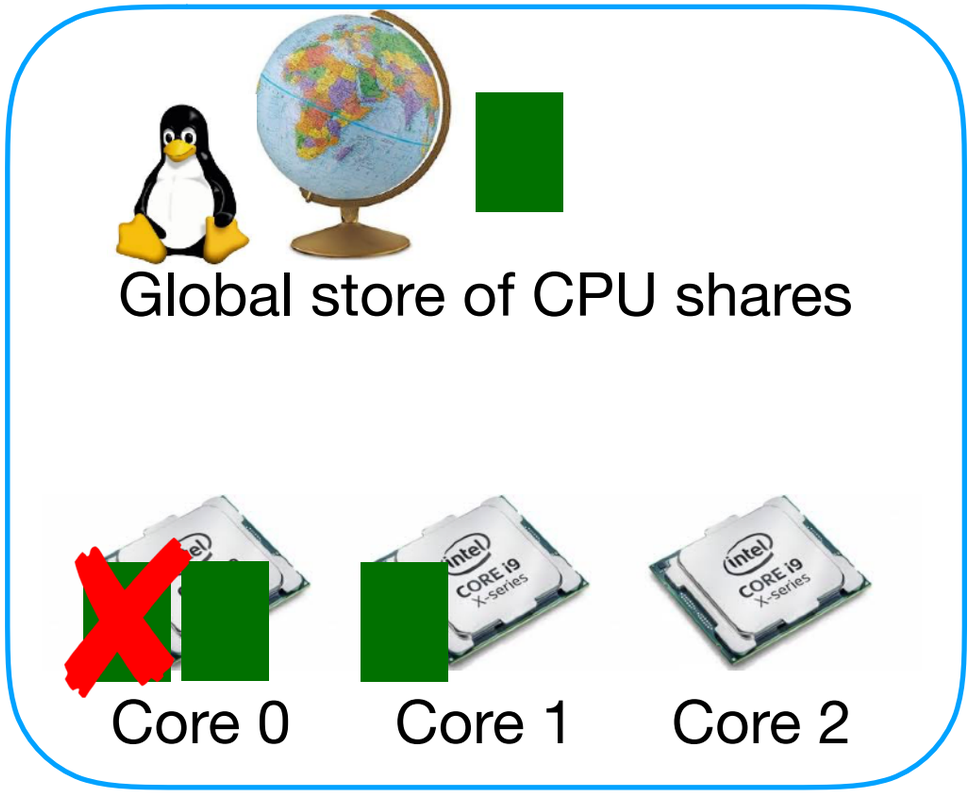

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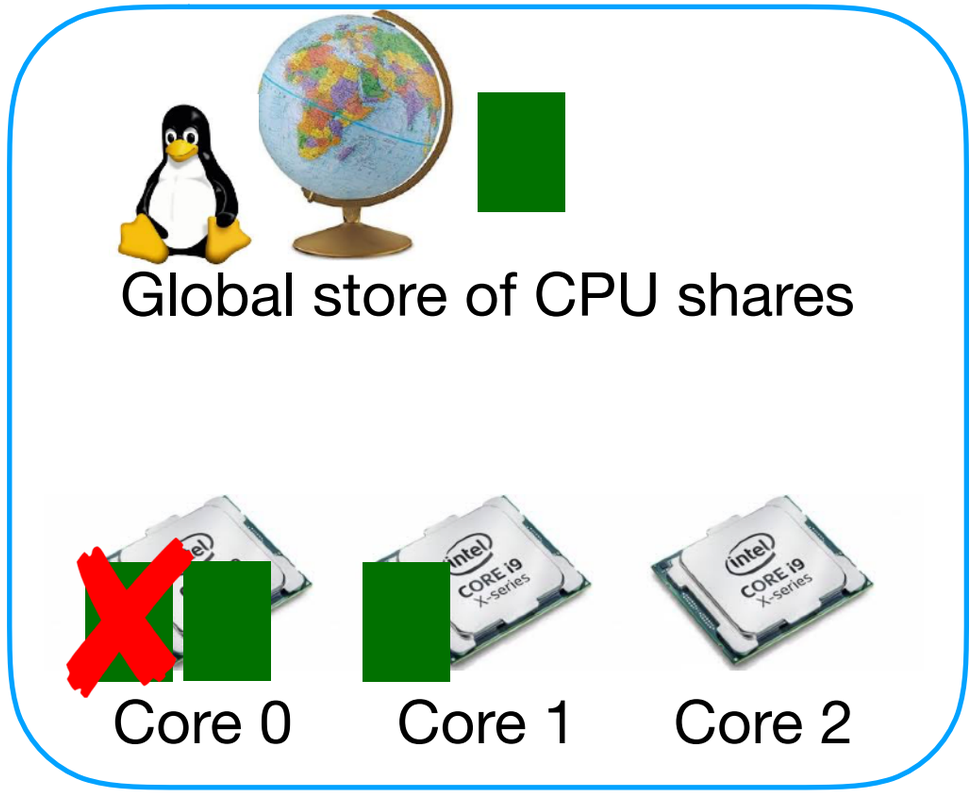

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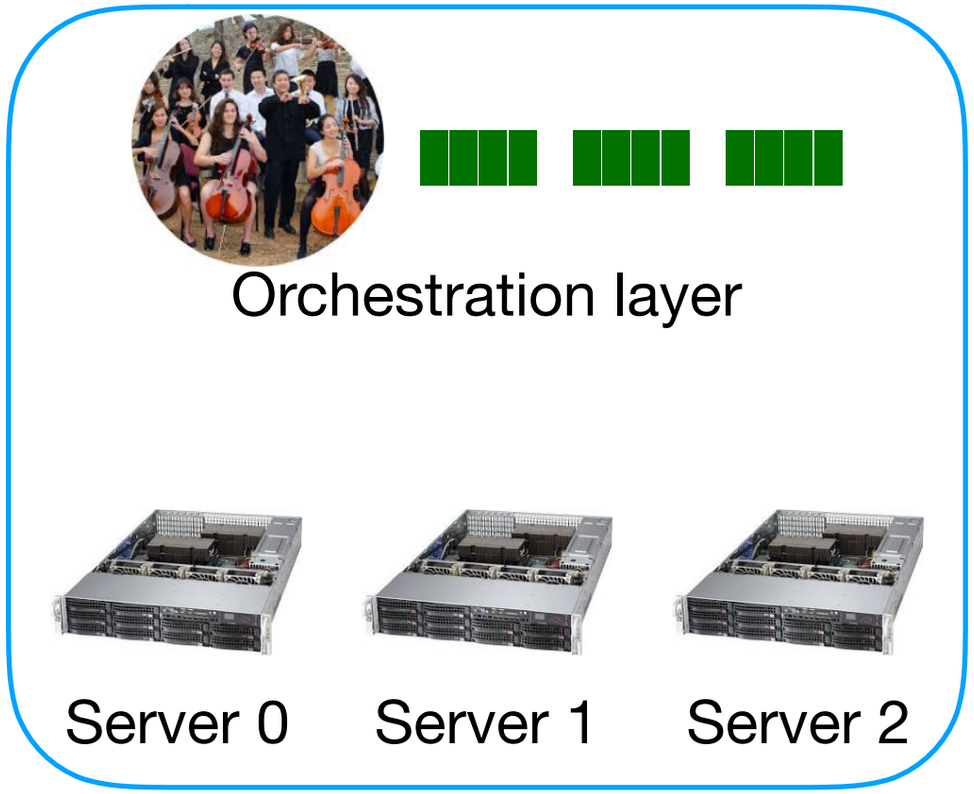

… to ServerlessOS

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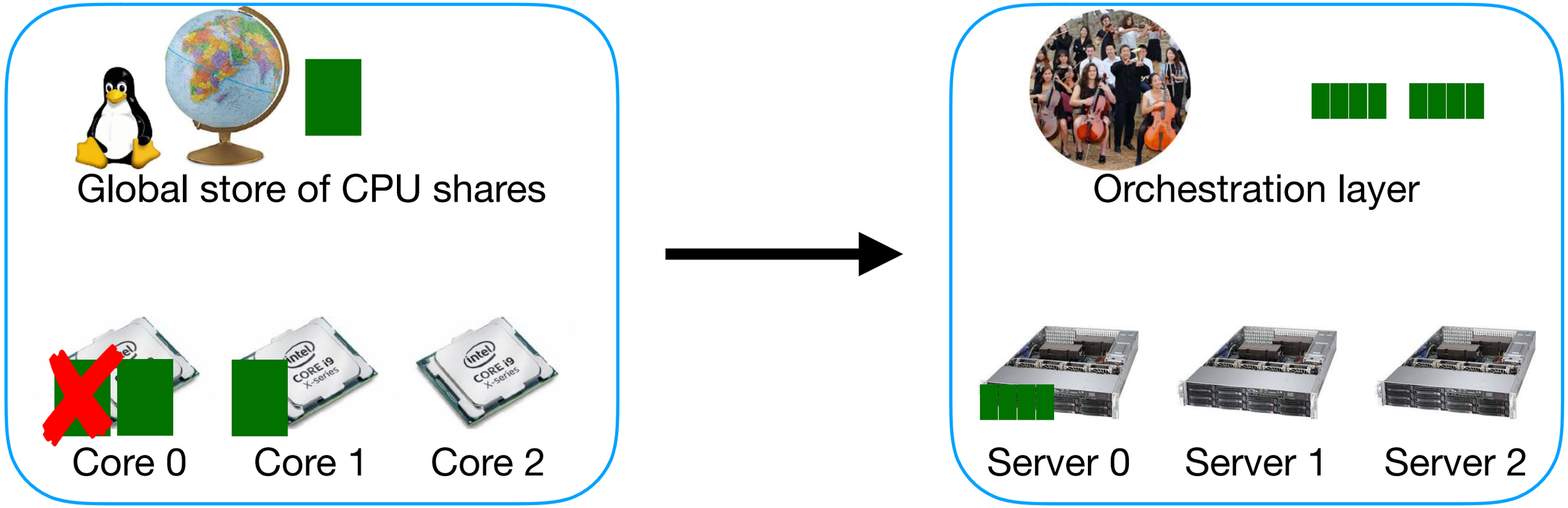

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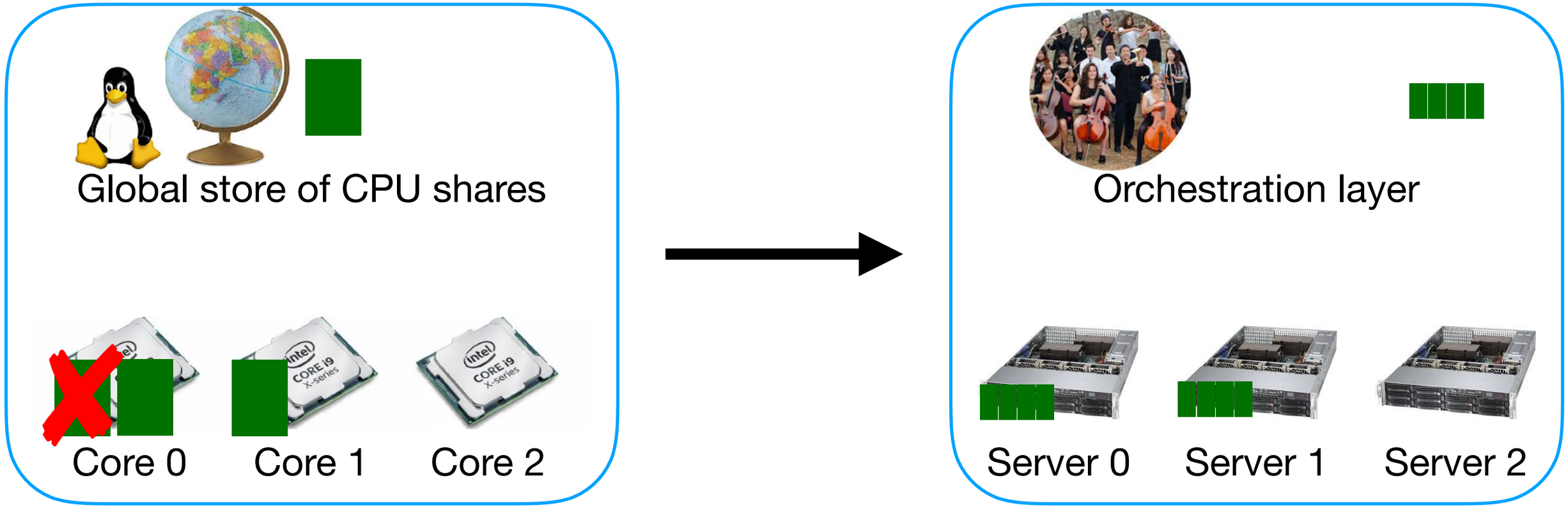

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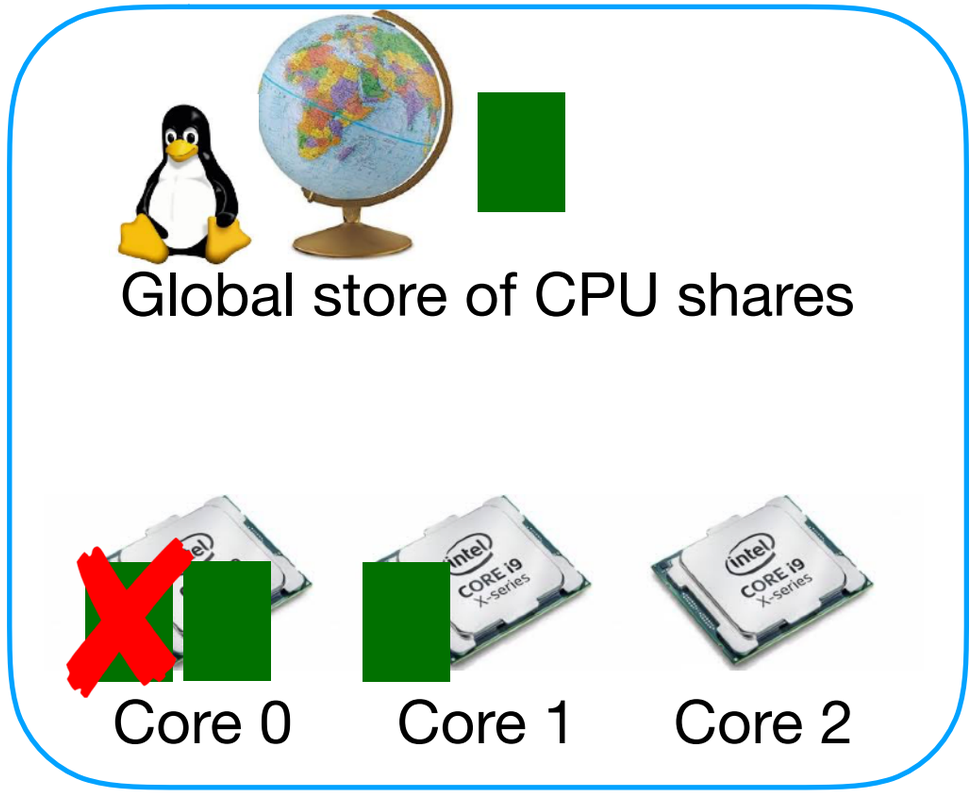
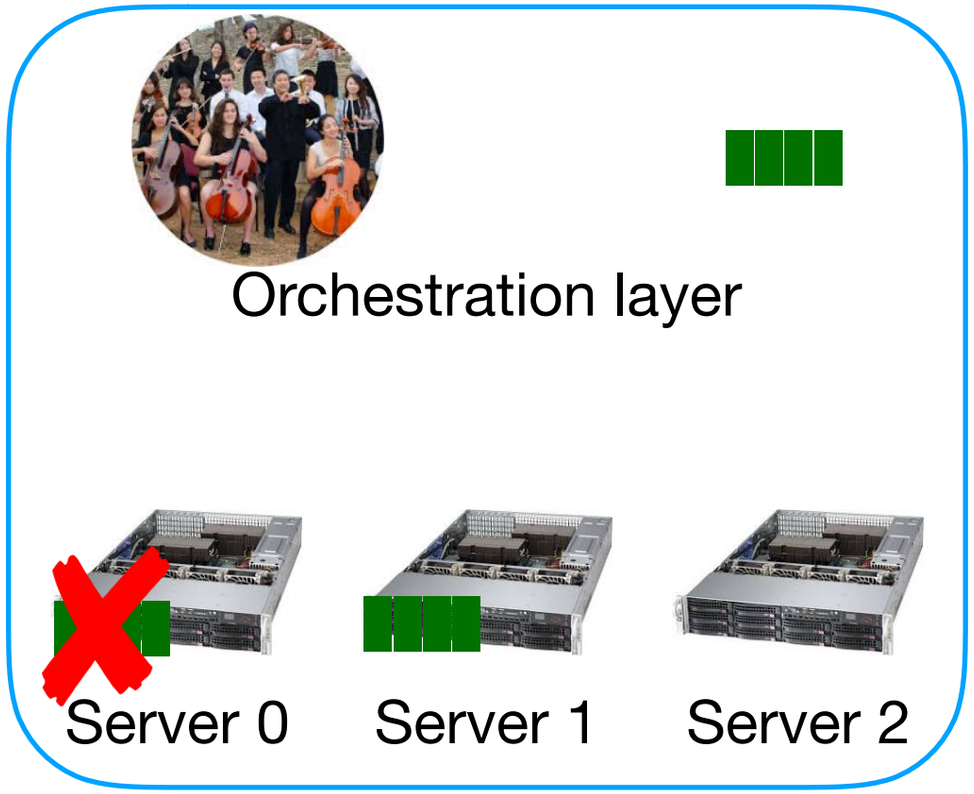


From single server…



… to ServerlessOS

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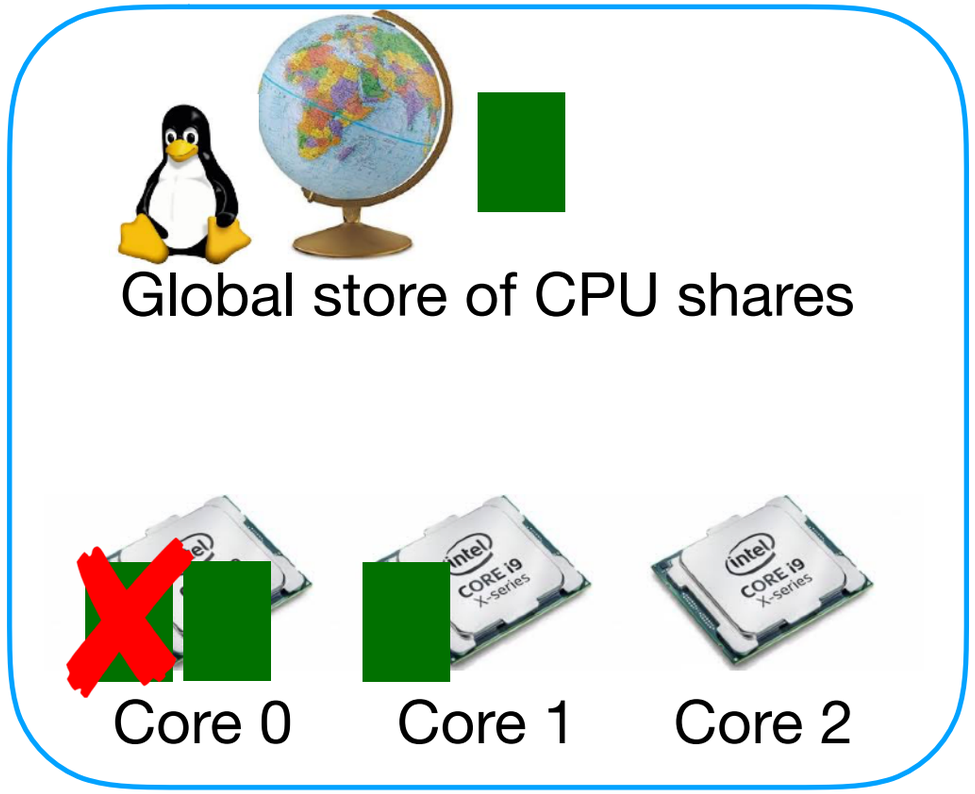
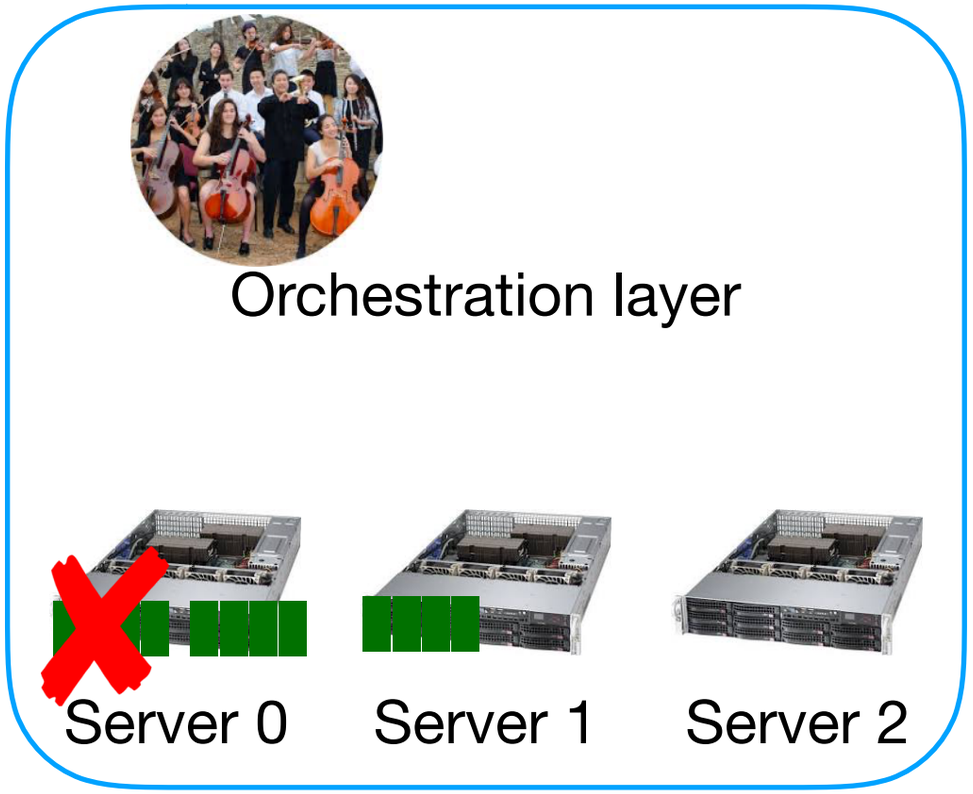


From single server…



… to ServerlessOS

Conclusions

- New abstraction for serverless: a seamless, scale-out process
- High-level overview of ServerlessOS architecture
  - Fluid multi-resource disaggregation
  - Fine-grained live orchestration layer
  - Coordinated isolation
- Next steps: refine design, build prototype, conquer the world!
- Thanks! mailto: erozner@us.ibm.com