Making Serverless Computing More Serverless

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* Views not representative of IBM policy, products, or strategies

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

Making Serverless Computing More Serverless

FaaS, Lamda, OpenWhisk, …

Break limitations of single server

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***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

This talk: propose new serverless abstraction and overview its design

A new serverless abstraction

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


Flexible enough to support general set of applications


Familiar to developers, operating systems, and admins


Easy to transition existing codebases to serverless


Same simplicity and scale-out as FaaS

A new serverless abstraction

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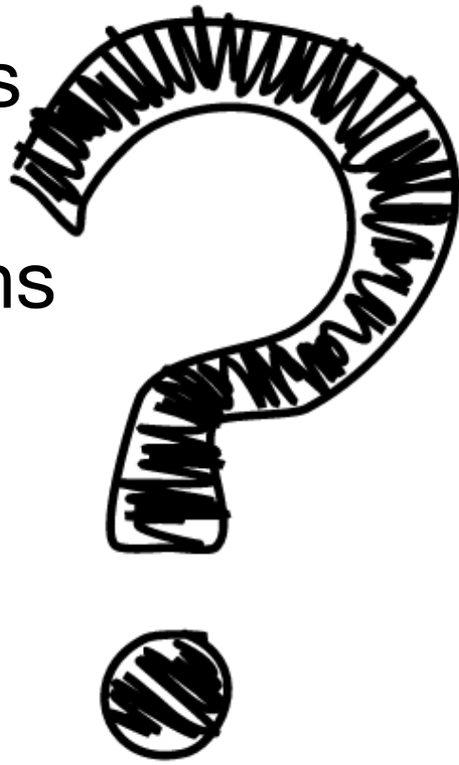
- Familiar to developers, operating systems, and admins
- Easy to transition existing codebases to serverless
- Same simplicity and scale-out as FaaS



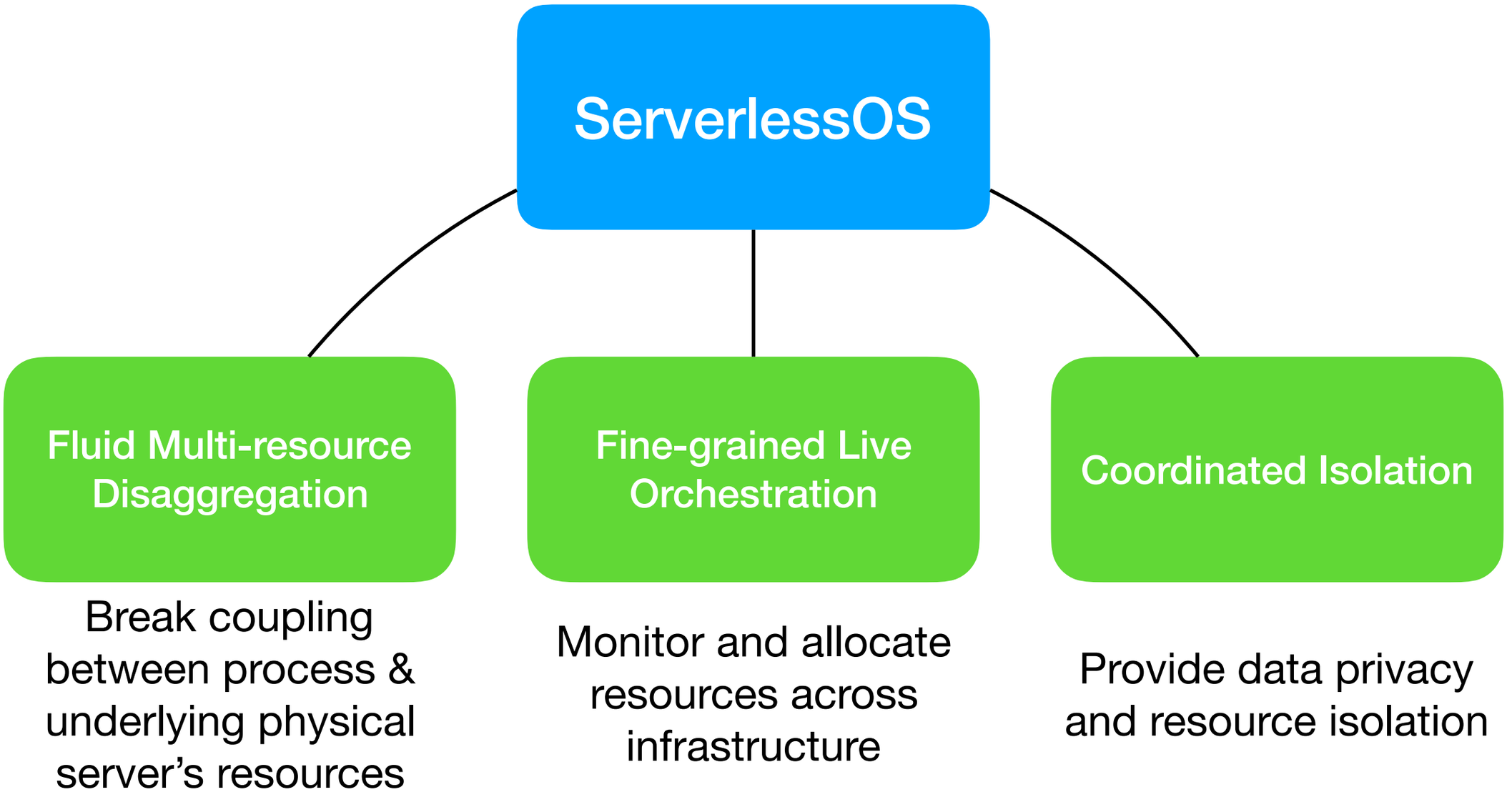
A Process!

- ✓ Flexible enough to support general set of applications
  - ★ Multiple threads, I/O via sockets, persist state, …
- ✓ Familiar to developers, operating systems, and admins
  - ★ Abstraction already used today in non-serverless
- ✓ Easy to transition existing codebases to serverless
  - ★ Pool of CPU, I/O, memory, storage: *server* → *datacenter*
- ✗ Same simplicity and scale-out as FaaS

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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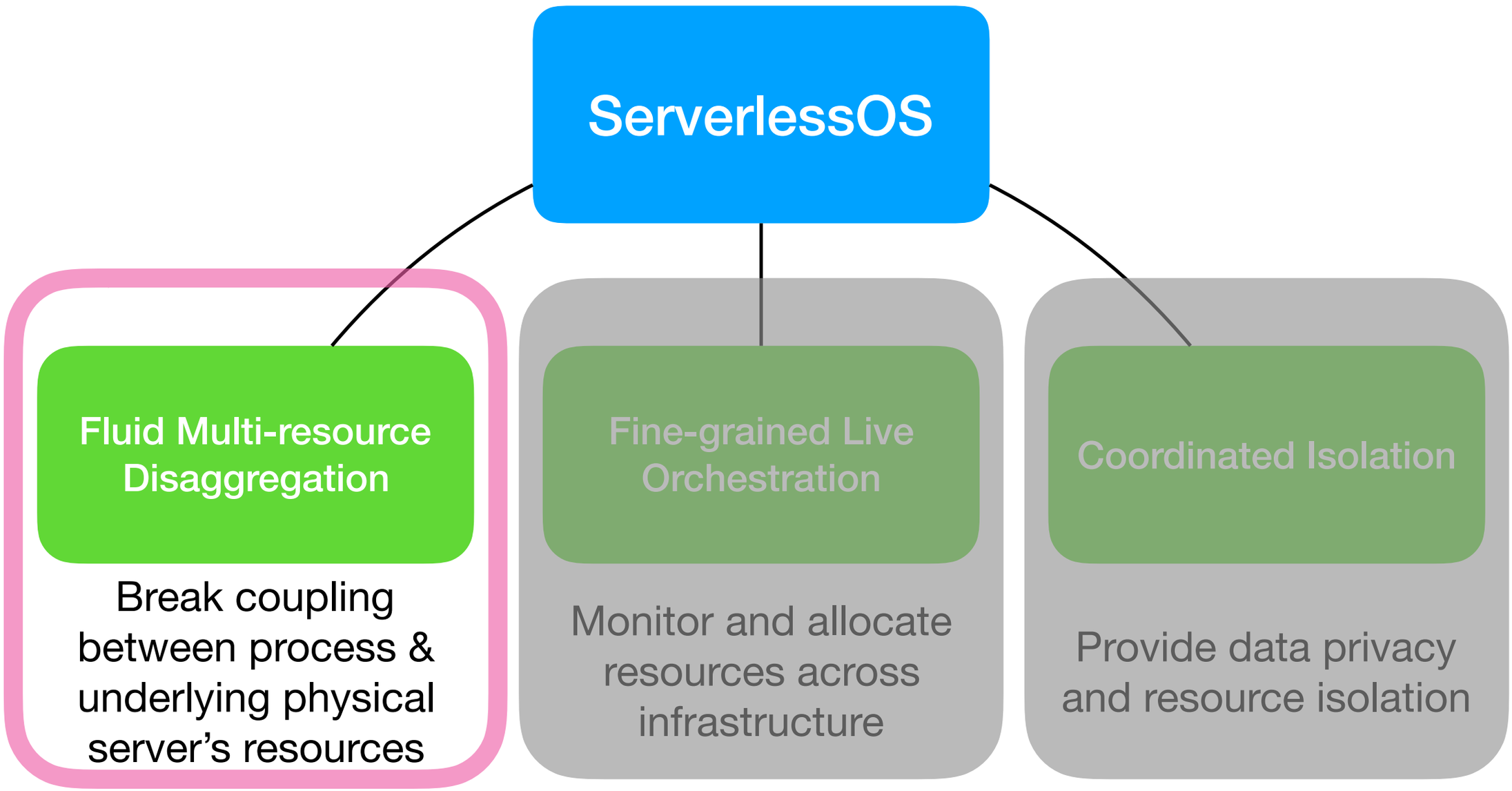


Fluid multi-resource disaggregation

- Break coupling between process & underlying physical server resources

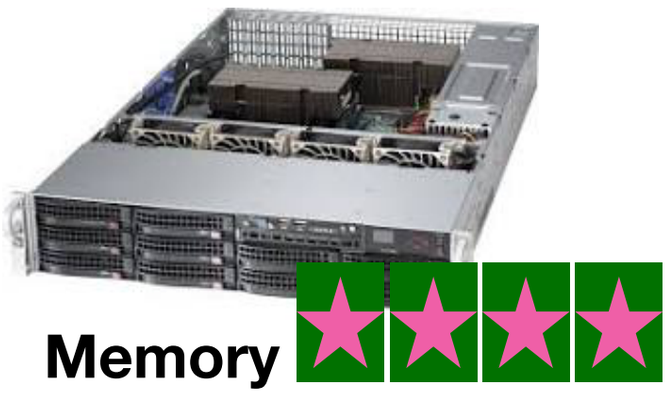
Fluid multi-resource disaggregation

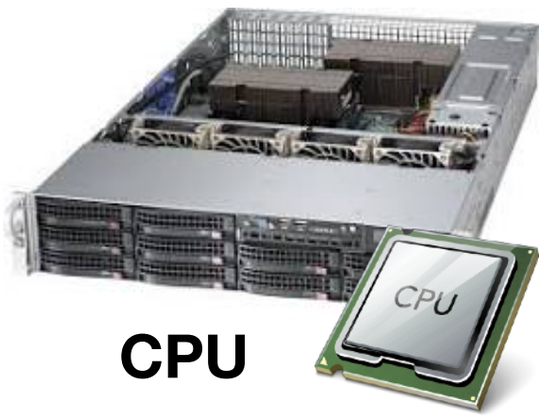
Disaggregation: decouple process's resources from single server

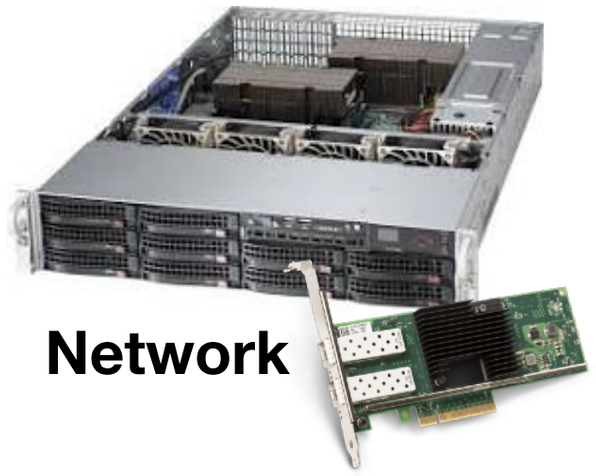
Fluid multi-resource disaggregation

- Break coupling between process & underlying physical server resources

Fluid multi-resource disaggregation





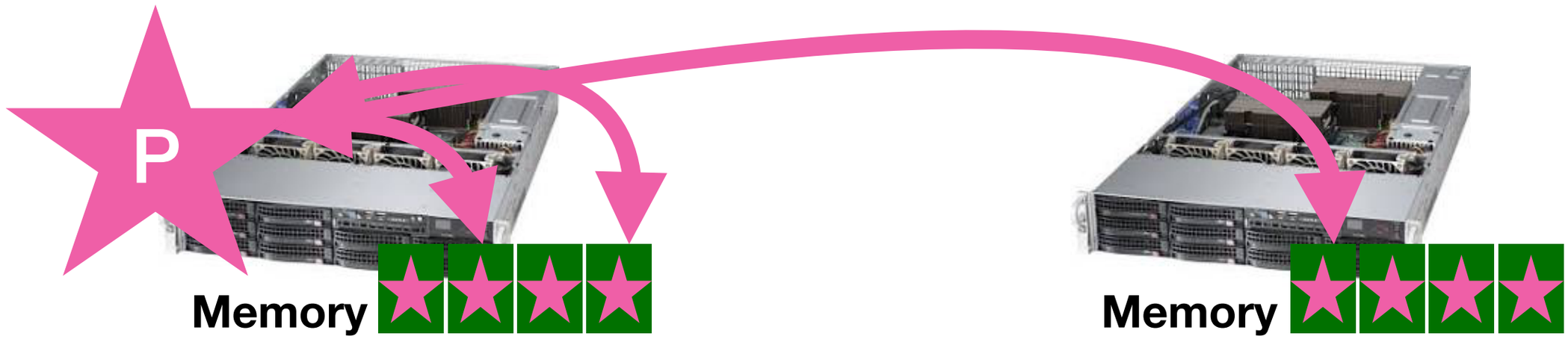


Decouple memory, compute, I/O to increase flexibility

Fluid multi-resource disaggregation

- Break coupling between process & underlying physical server resources

Fluid multi-resource disaggregation

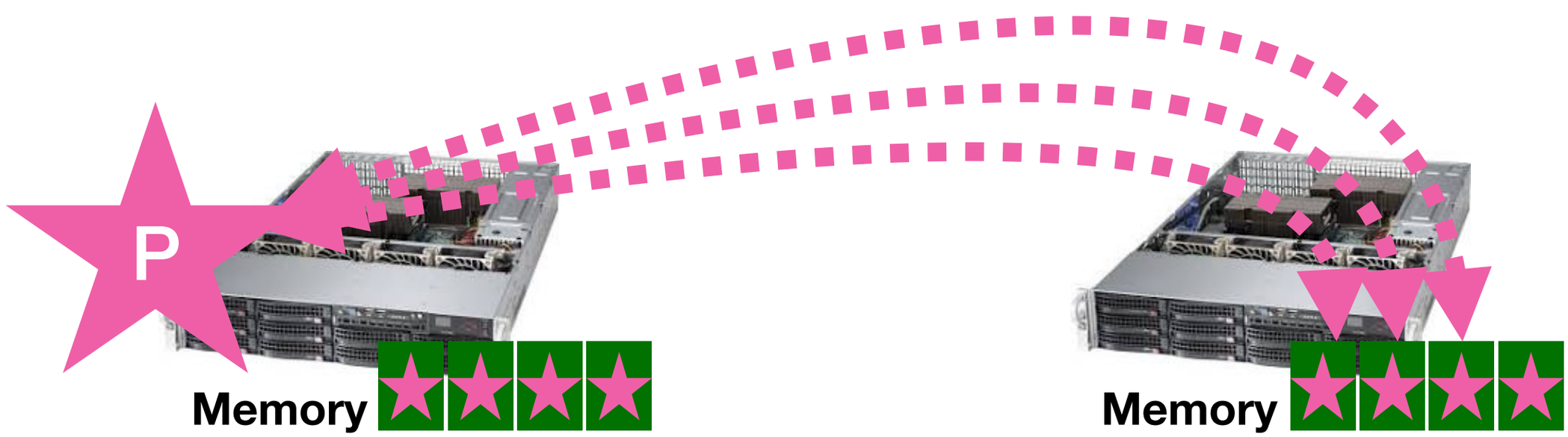


Acessing remote memory incurs much higher overhead than local memory

Fluid multi-resource disaggregation

- Break coupling between process & underlying physical server resources

Fluid multi-resource disaggregation

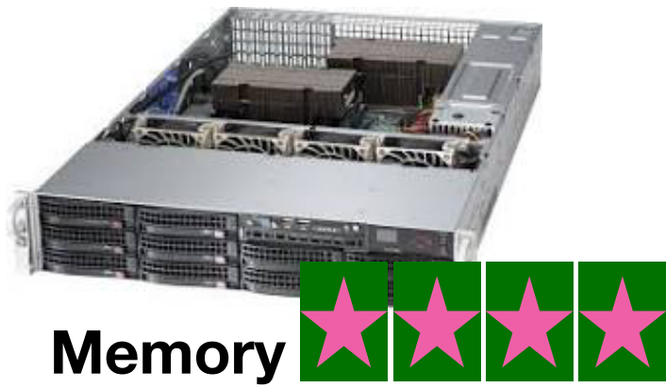


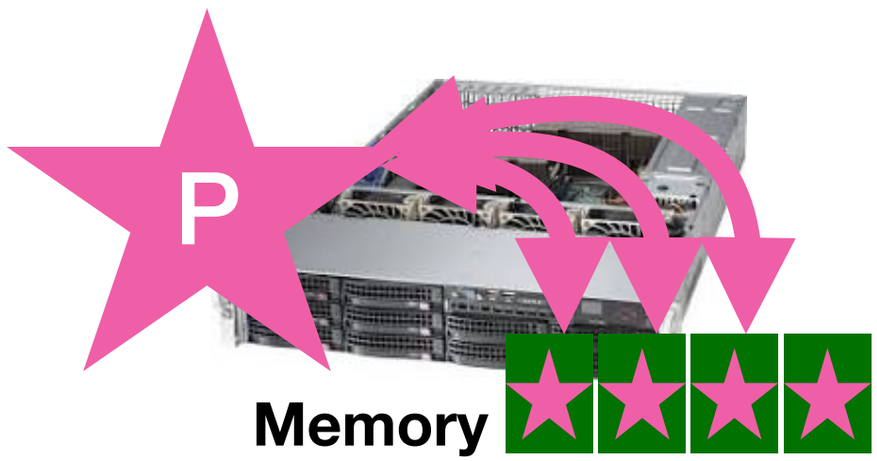
Fluidity: allow process to *move to* data when more efficient

Fluid multi-resource disaggregation

- Break coupling between process & underlying physical server resources

Fluid multi-resource disaggregation



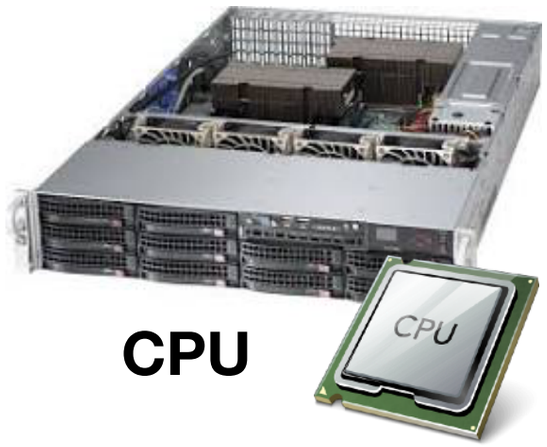


Fluidity: enable process to exploit locality to improve performance

Fluidity over multiple resources

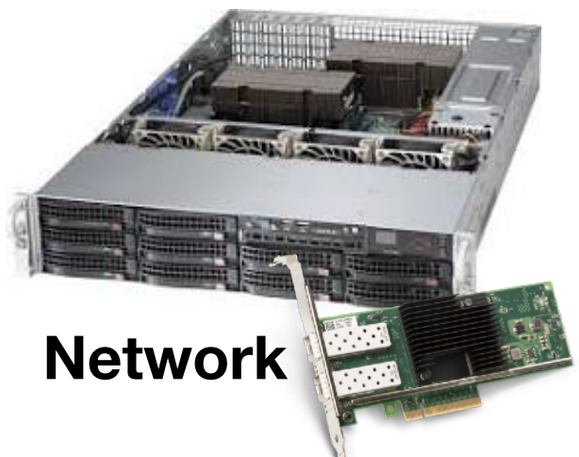
Memory

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



CPU

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



Network

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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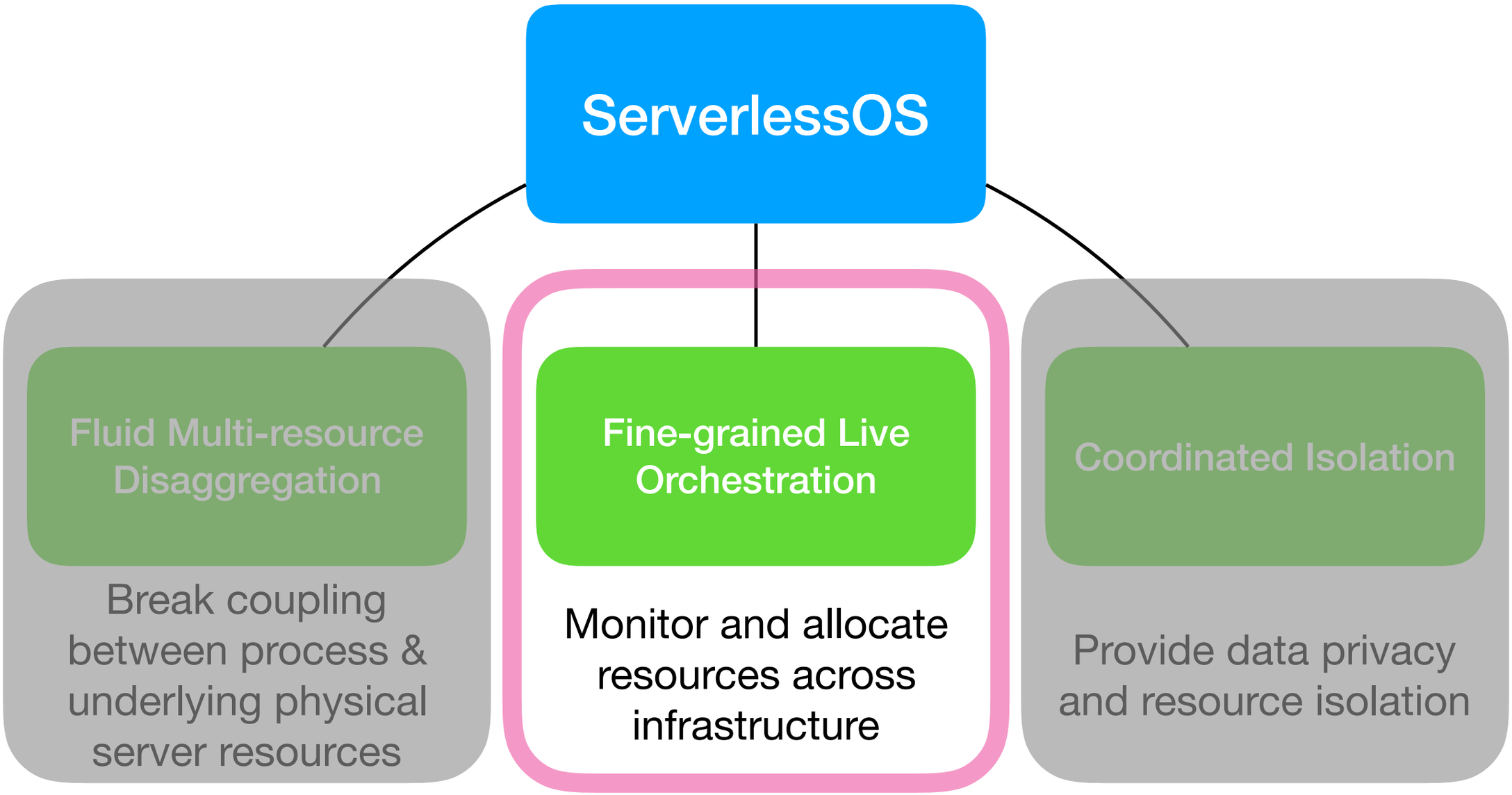


Fine-grained live orchestration layer

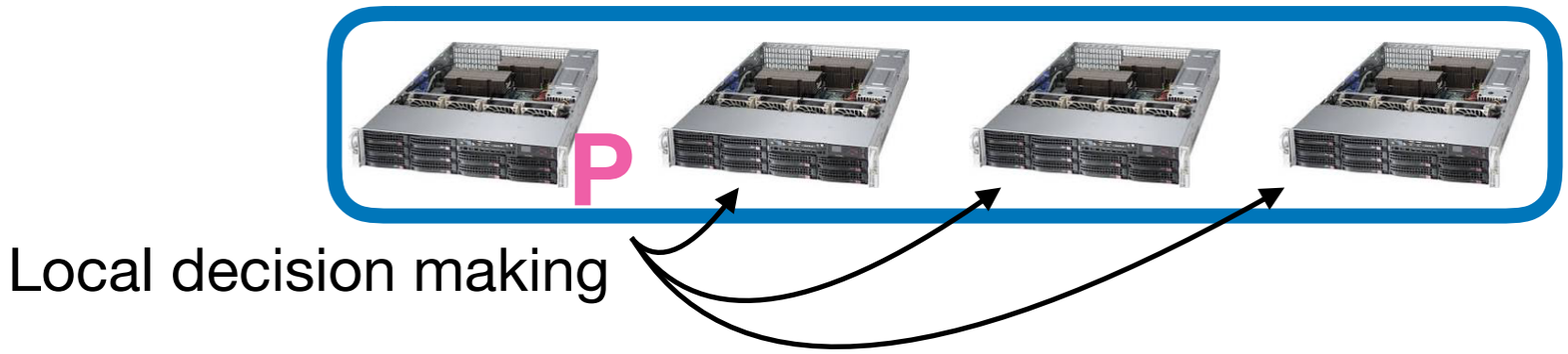
- Monitor, allocate, and optimize run-time performance by automatically assigning, migrating, or scaling workloads

Global decision making

Determine subset of nodes (and resources) available to process P

Fine-grained live orchestration layer

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



- 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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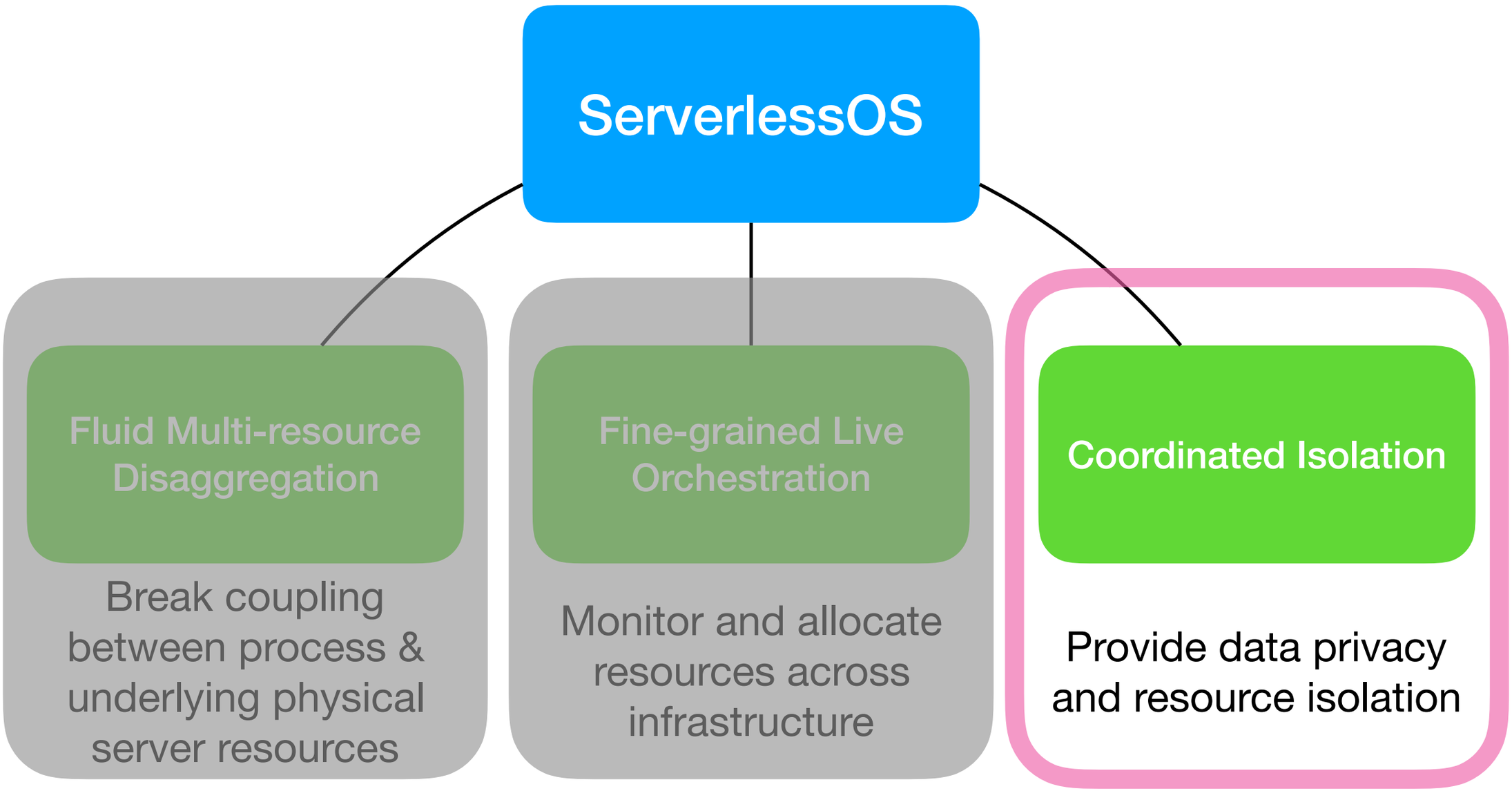


Coordinated Isolation

Data Privacy

Ensure application cannot read or write state from another application

Resource Isolation

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

namespaces

control groups

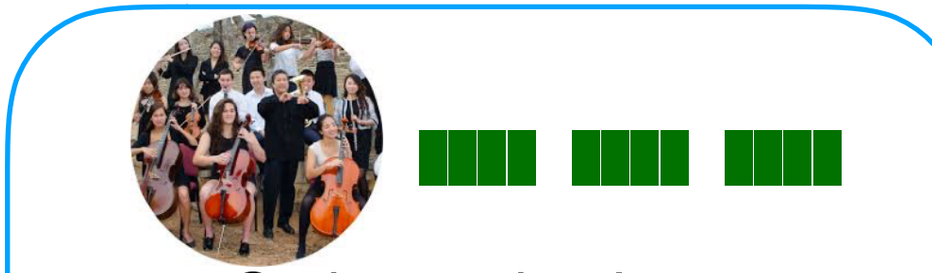
Linux Kernel

ServerlessOS: extend isolation across multiple servers in coordinated fashion

Coordinated Isolation

namespaces	Extend process namespace across multiple servers
control groups	Centralize state in orchestration layer, but minimize overheads

From single server…



… to ServerlessOS

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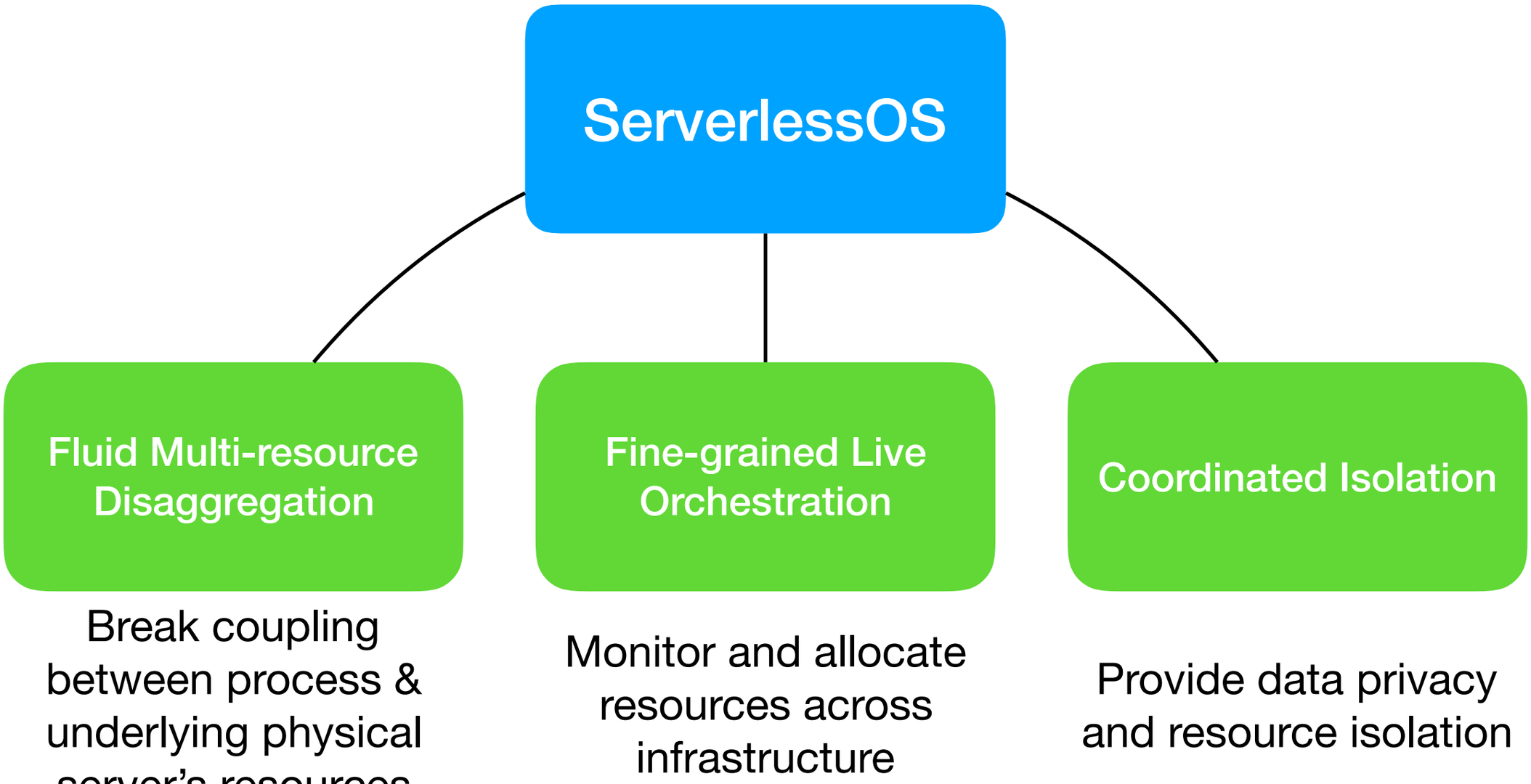

Conclusions

- 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
- Complementary to current serverless techniques
- Next steps: refine design, build prototype, conquer the world!
- Thanks! mailto: erozner@us.ibm.com