pocket

Elastic Ephemeral Storage for Serverless Analytics

Ana Klimovic[*], Yawen Wang[*], Patrick Stuedi[+], Animesh Trivedi[+], Jonas Pfefferle[+], Christos Kozyrakis[*]

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OSDI 2018

Serverless Computing

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- Serverless computing is increasingly used for **interactive analytics**

PyWren (SoCC'17)

ExCamera (NSDI'17)

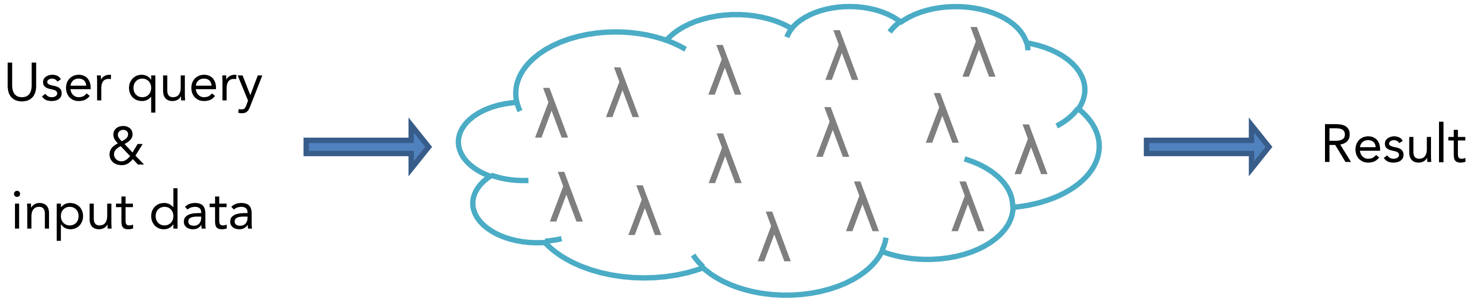
databricks serverless

gg: The Stanford Builder

Amazon Aurora Serverless

Serverless Computing

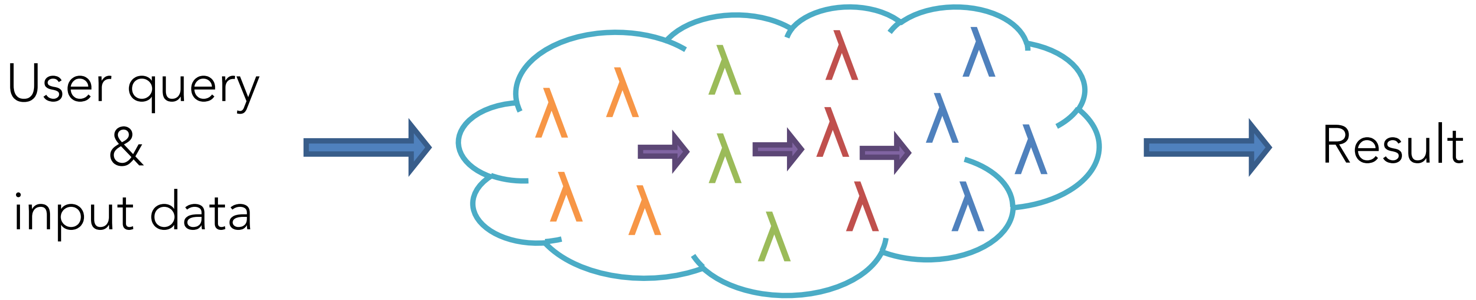
- Serverless computing enables users to launch short-lived tasks with high elasticity and fine-grain resource billing
- Serverless computing is increasingly used for **interactive analytics**
  - Exploit massive parallelism with large number of serverless tasks



The Challenge: Data Sharing

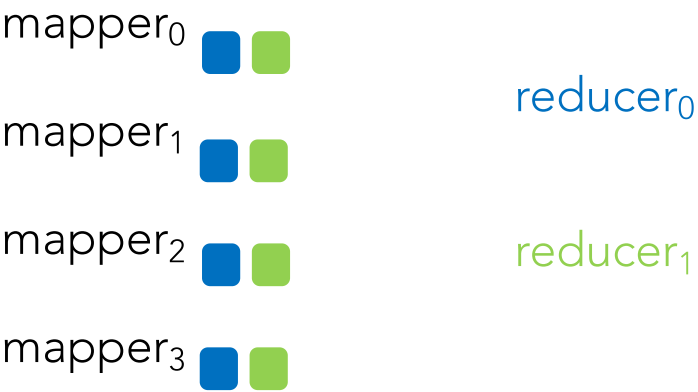
- Analytics jobs involve multiple stages of execution
- Serverless tasks need an efficient way to communicate **intermediate data** between different stages of execution

ephemeral data



In traditional analytics…

- Ephemeral data is exchanged directly between tasks



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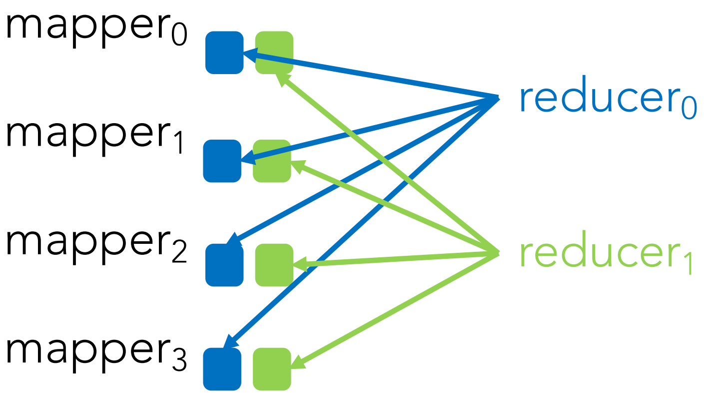
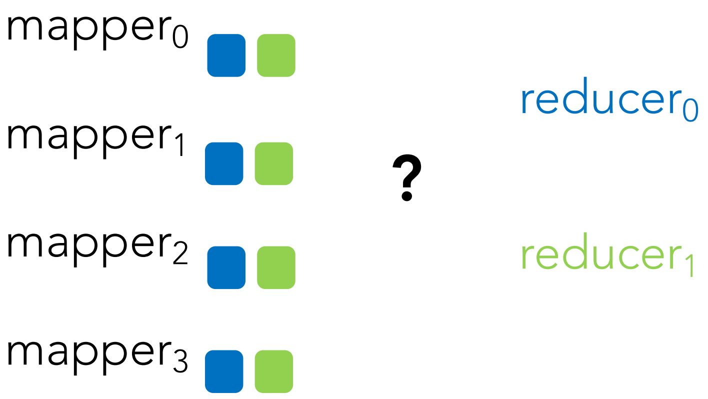


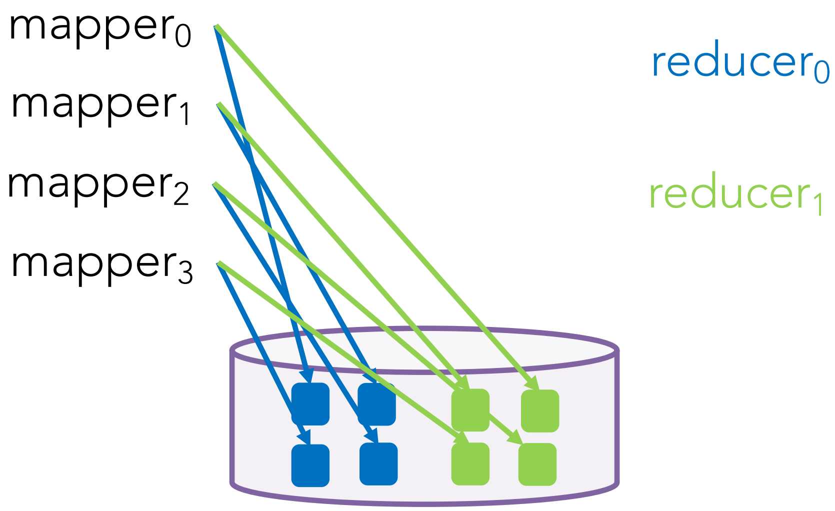
In serverless analytics…

- Direct communication between serverless tasks is difficult:
  - Tasks are short-lived and stateless



In serverless analytics…

- The natural approach for sharing ephemeral data is through a common data store



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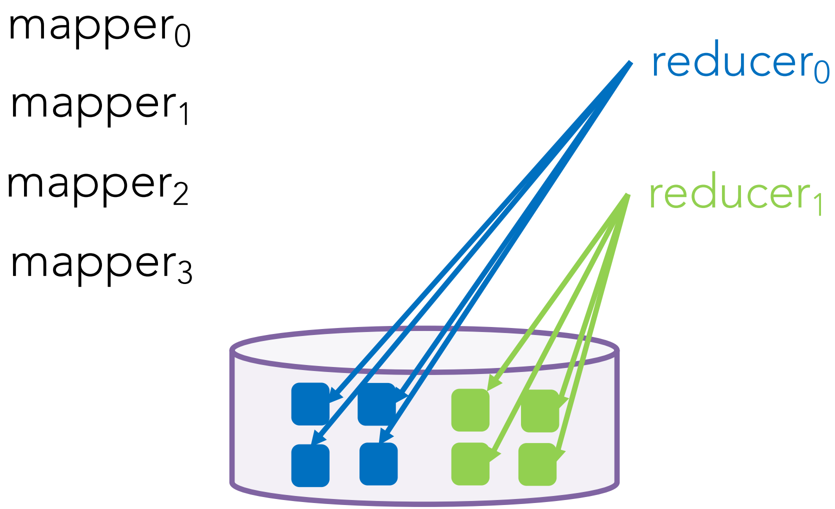


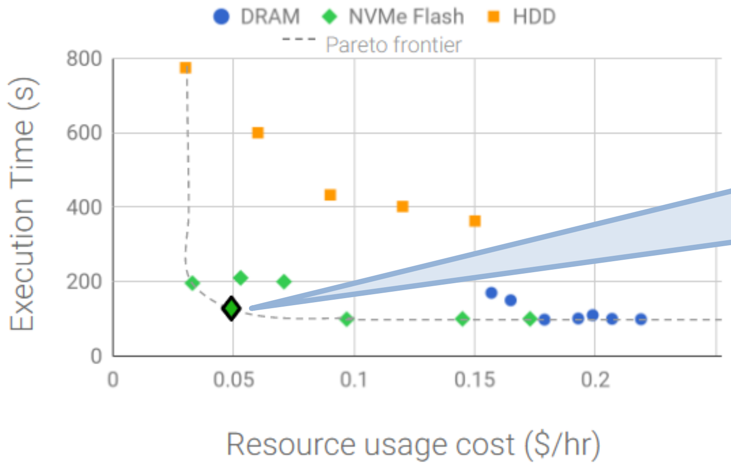
Requirements for Ephemeral Storage

1. High performance for a wide range of object sizes
2. Cost efficiency, i.e., fine-grain, pay-what-you-use resource billing

Understanding Ephemeral Storage for Serverless Analytics. Ana Klimovic, Yawen Wang, Christos Kozyrakis, Patrick Stuedi, Jonas Pfefferle, Animesh Trivedi. **ATC'18**, 2018.

Requirements for Ephemeral Storage

1. High performance for a wide range of object sizes
2. Cost efficiency, i.e., fine-grain, pay-what-you-use resource billing
   - Example of performance-cost tradeoff for a serverless video analytics job with different ephemeral data store configurations



Finding the Pareto optimal resource allocation is non-trivial…and gets harder with multiple jobs.

Requirements for Ephemeral Storage

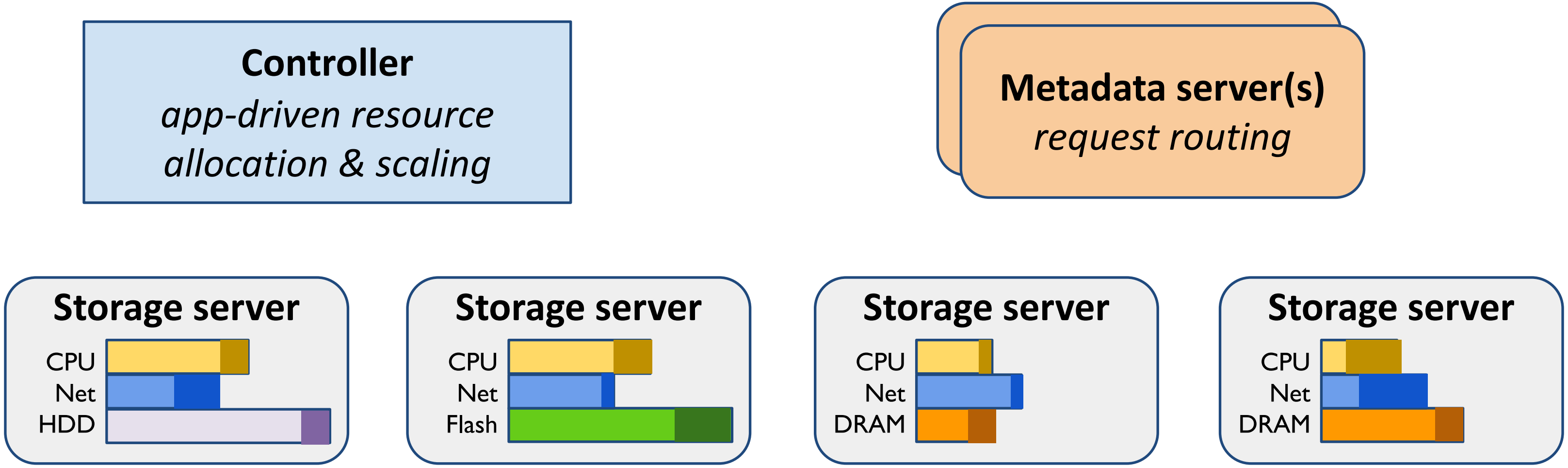
1. High performance for a wide range of object sizes
2. Cost efficiency, i.e., fine-grain, pay-what-you-use resource billing
3. ~~Fault-tolerance~~

Existing cloud storage systems do not meet the elasticity, performance and cost demands of serverless analytics jobs.

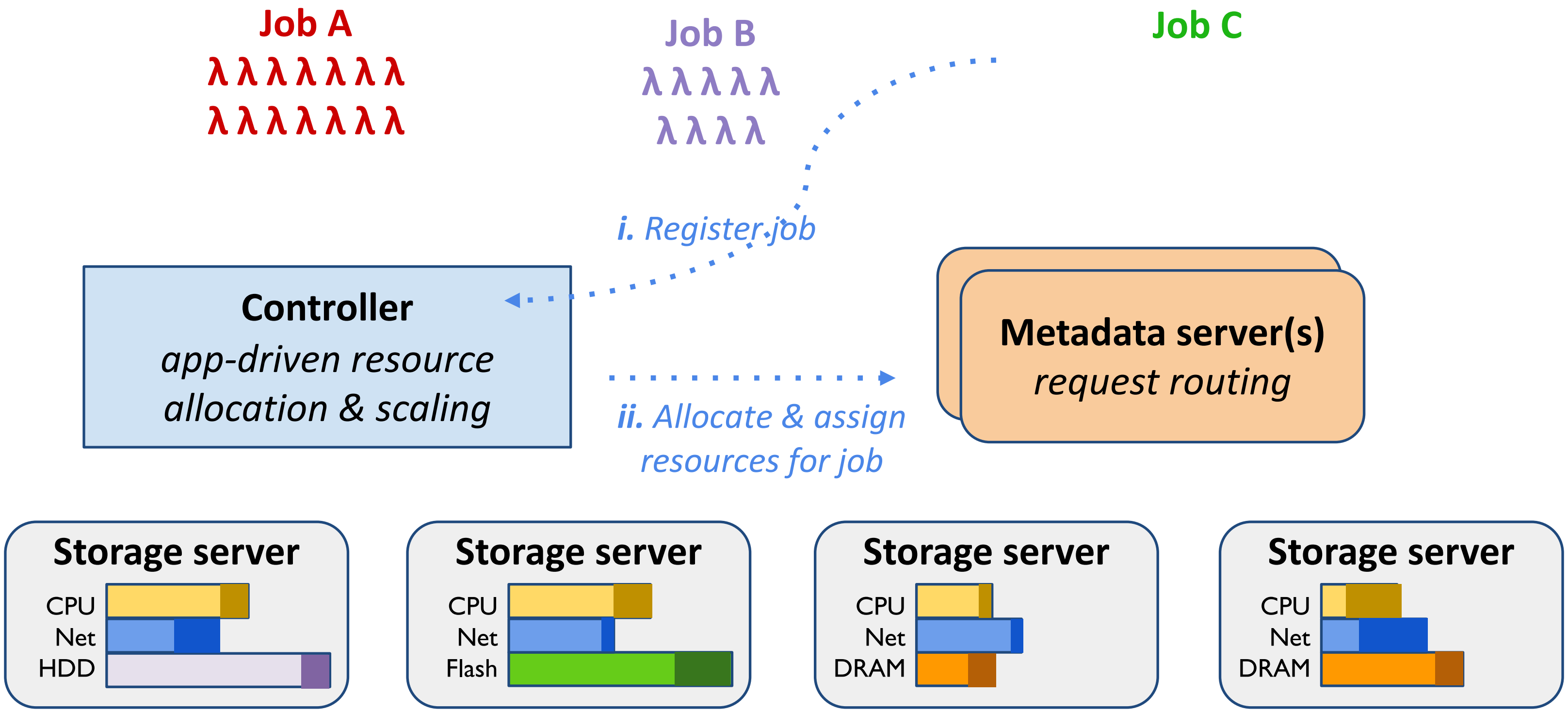
Pocket

- An elastic, distributed data store for ephemeral data sharing in serverless analytics
- Pocket achieves high performance and cost efficiency by:
  - Leveraging multiple storage technologies
  - Rightsizing resource allocations for applications
  - Autoscaling storage resources in the cluster based on usage
- Pocket achieves similar performance to Redis, an in-memory key value store, while saving ~60% in cost for various serverless analytics jobs

Pocket Design



Using Pocket



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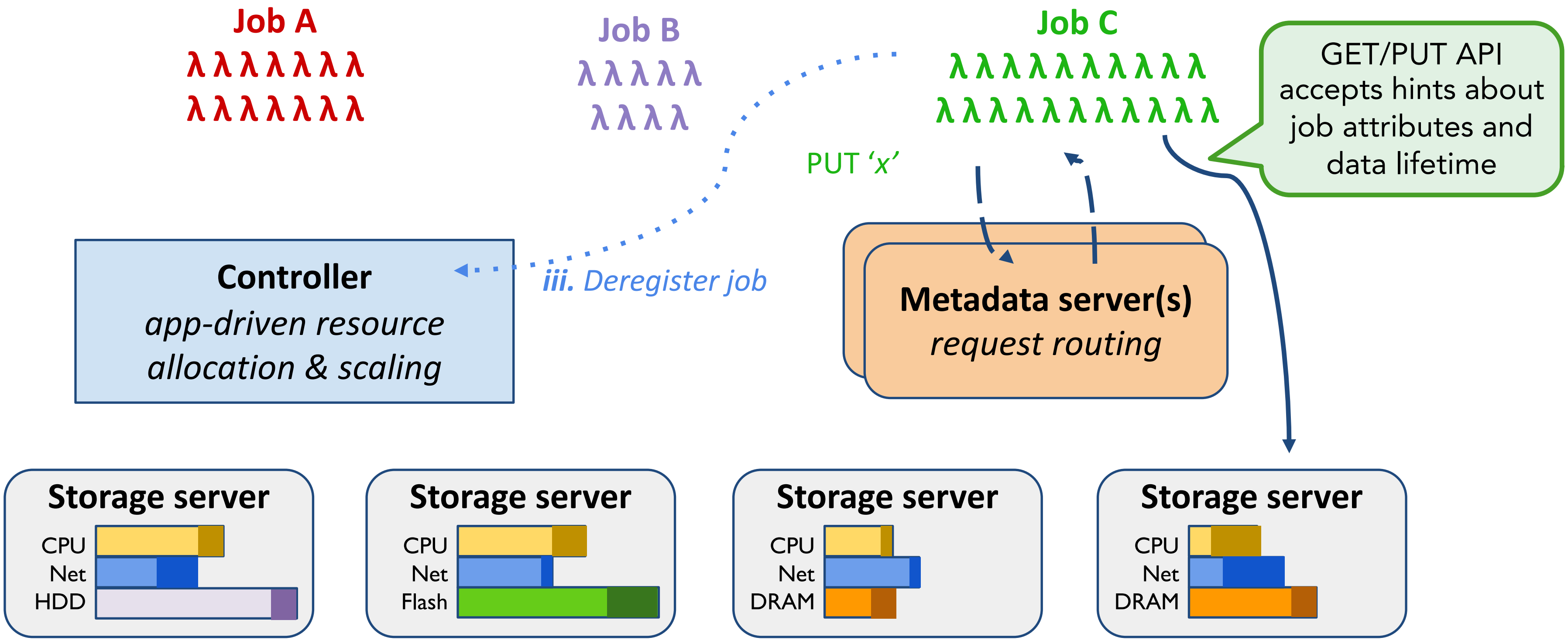
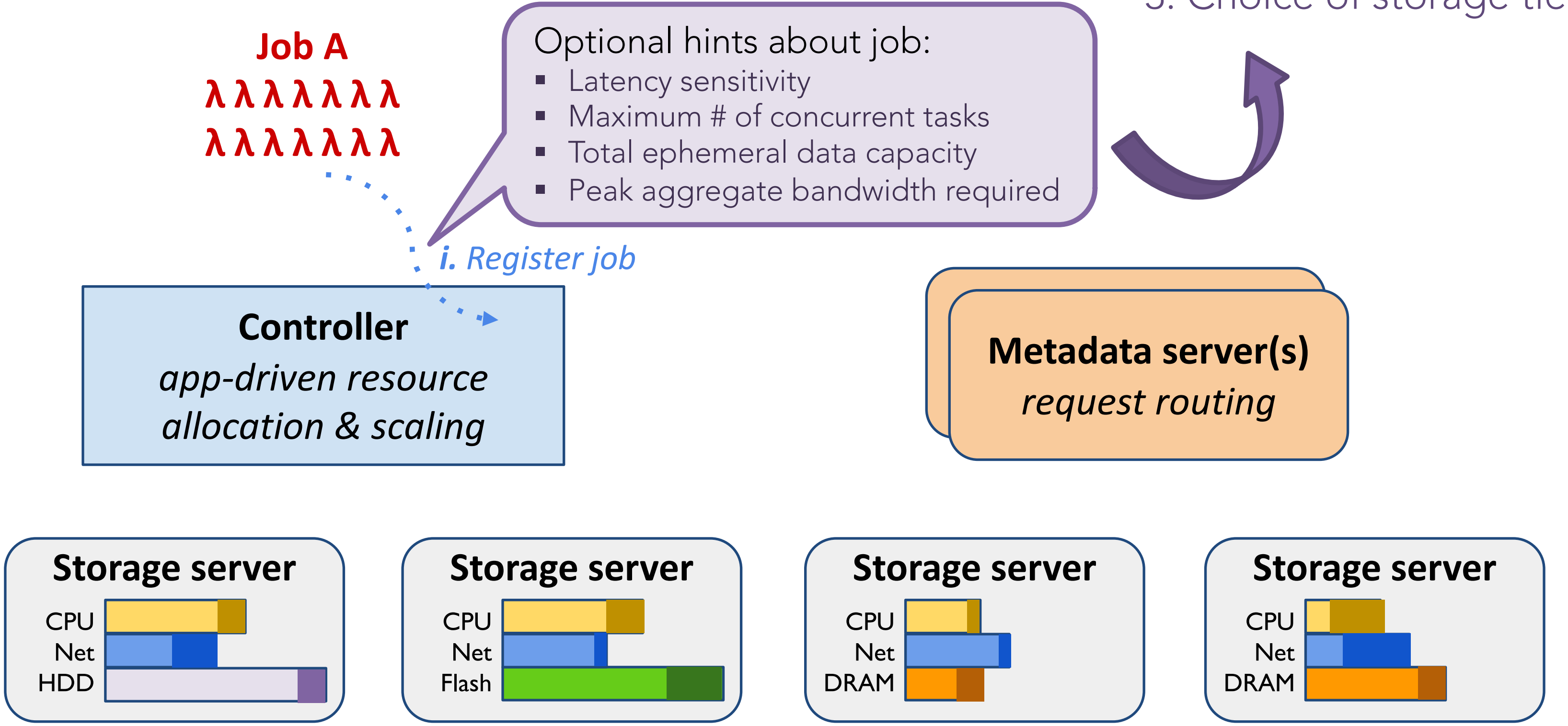


Assigning Resources to Jobs

1. Throughput allocation
2. Capacity allocation
3. Choice of storage tier(s)



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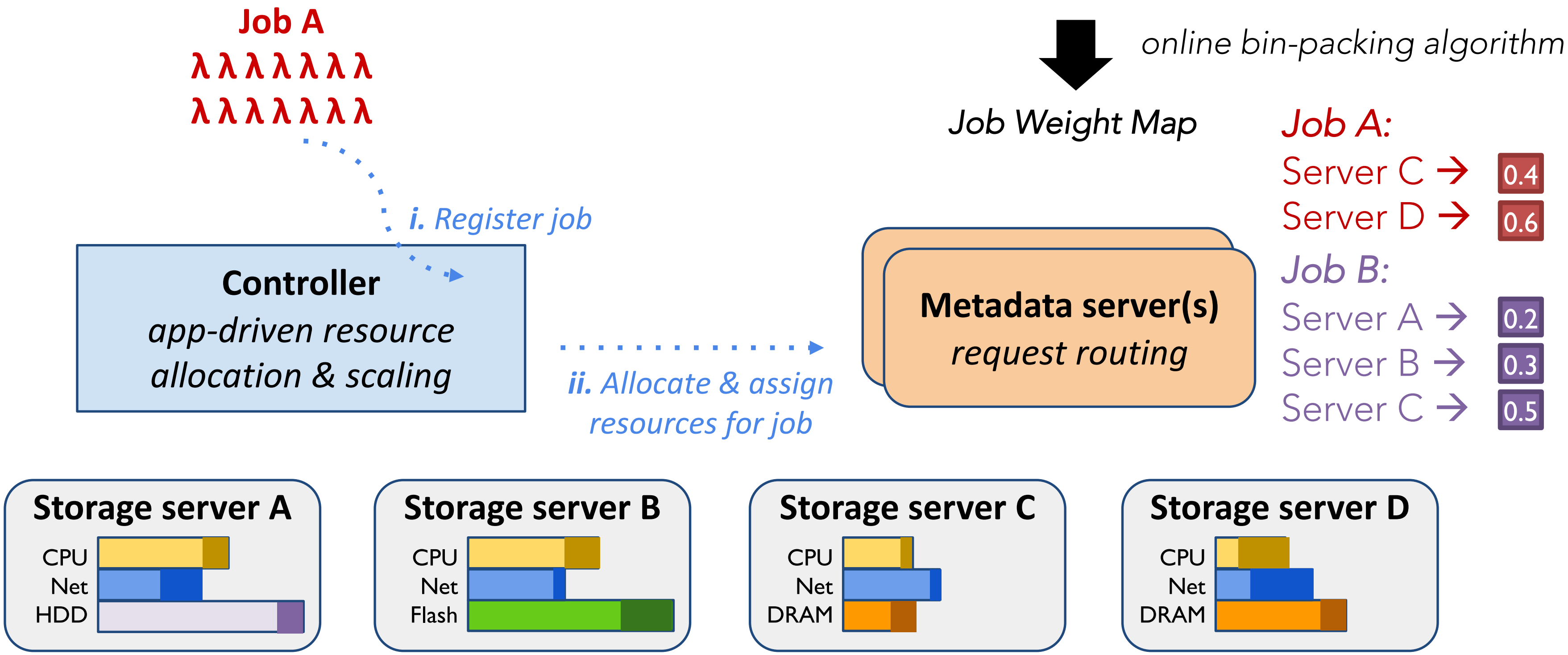


Autoscaling the Pocket Cluster

- Goal: scale cluster resources dynamically based on resource usage

- Mechanisms:
  - Monitor CPU, network bandwidth, and storage capacity utilization
  - Add/remove storage & metadata nodes to keep utilization within range
  - Steer data for incoming jobs to active nodes
  - Drain inactive nodes as jobs terminate

- Avoid migrating data

Implementation

- Pocket's metadata and storage server implementation is based on the **Apache Crail** distributed storage system [1]
- We use **ReFlex** for the Flash storage tier [2]
- Pocket runs the storage and metadata servers in containers, orchestrated using **Kubernetes** [3]

[1] Apache Crail (incubating). http://crail.apache.org/

[2] *ReFlex: Remote Flash == Local Flash*. Ana Klimovic, Heiner Litz, Christos Kozyrakis. **ASPLOS'17**, 2017.

[3] Kubernetes. https://kubernetes.io/

Pocket Evaluation

- We deploy Pocket on Amazon EC2

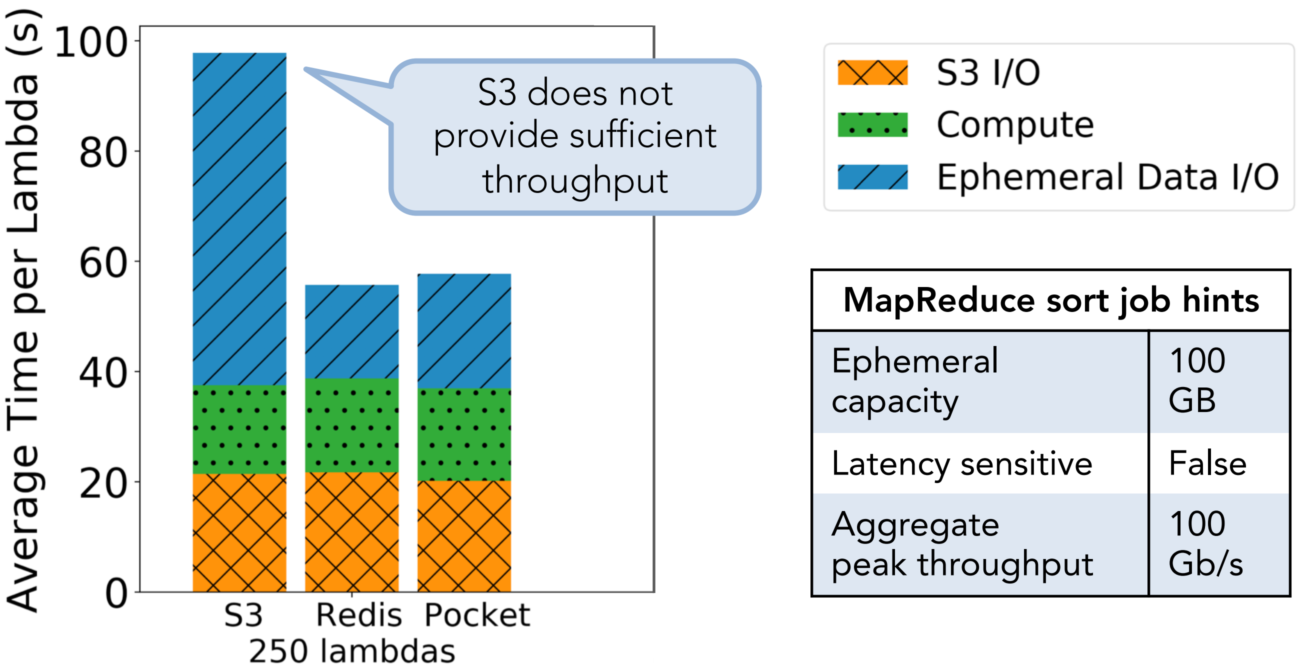
Controller	m5.xlarge
Metadata server	m5.xlarge
DRAM server	r4.2xlarge
NVMe Flash server	i3.2xlarge
SATA/SAS SSD server	i2.2xlarge
HDD server	h1.2xlarge

Amazon EC2

- We use AWS Lambda as our serverless platform
- **Applications**: MapReduce sort, video analytics, distributed compilation

Application Performance with Pocket

- Compare Pocket to S3 and Redis, which are commonly used today



MapReduce sort job hints	
Ephemeral capacity	100 GB
Latency sensitive	False
Aggregate peak throughput	100 Gb/s

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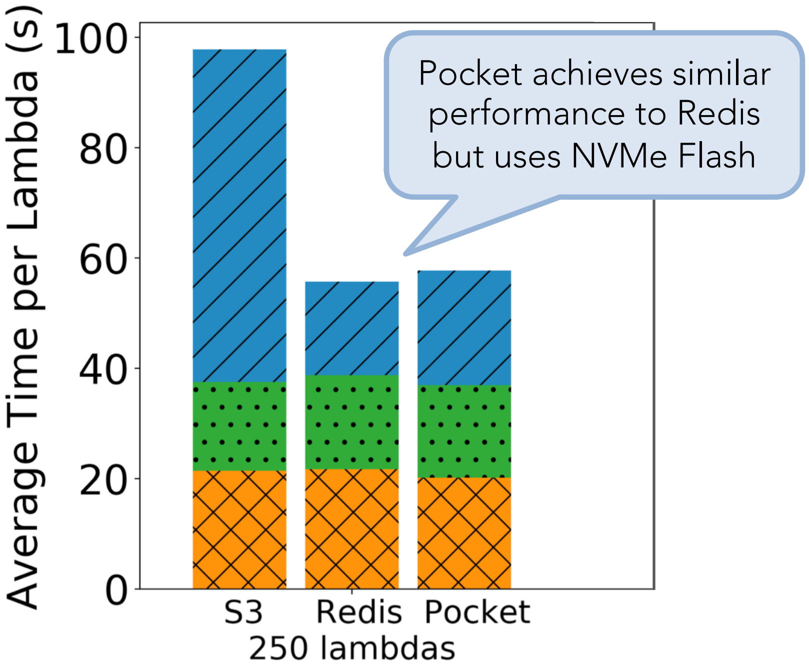

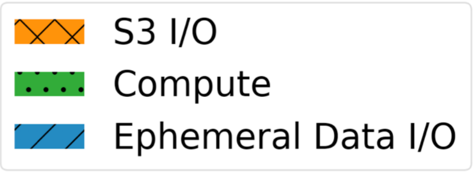

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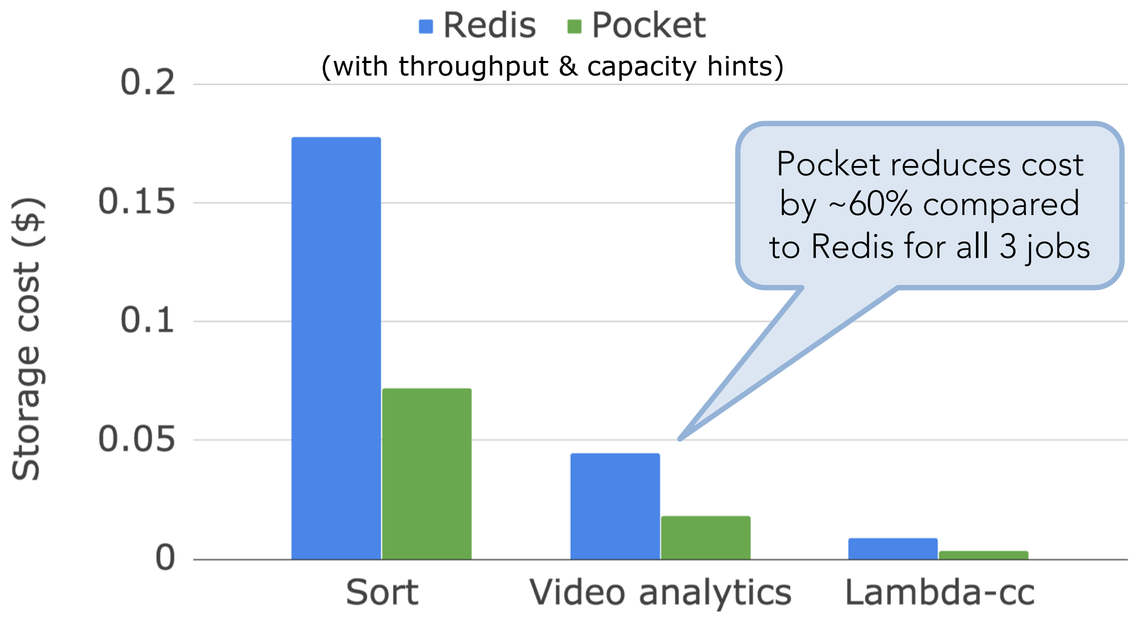
Application Storage Cost with Pocket

- Pocket leverages job attribute hints for cost-effective resource allocation and amortizes VM costs across multiple jobs, offering a pay-what-you-use model



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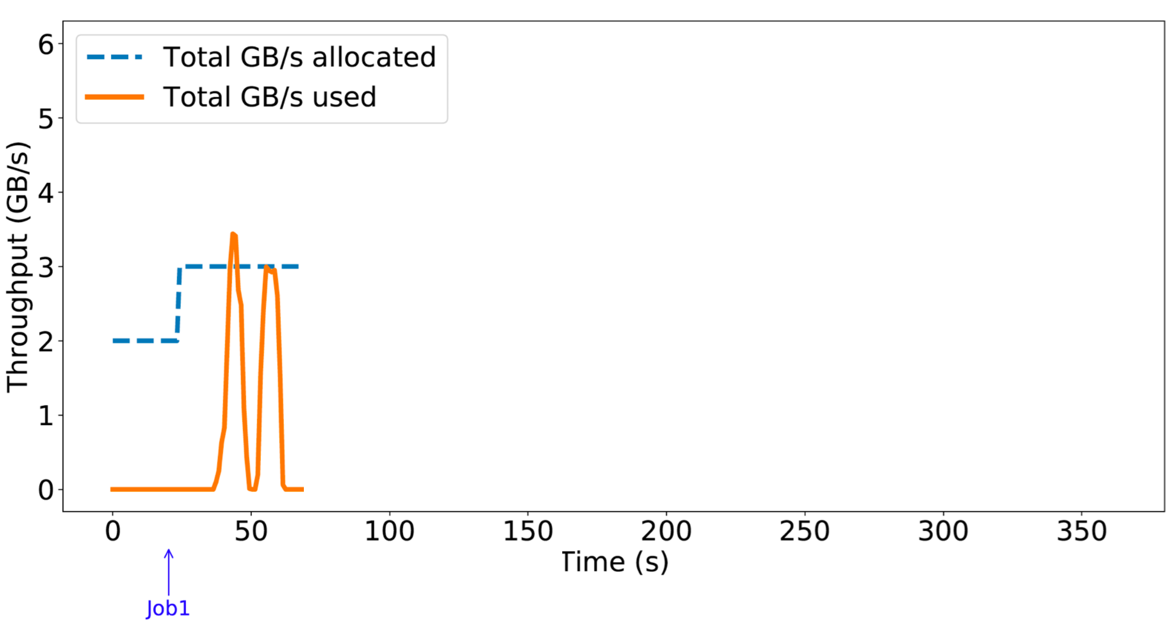
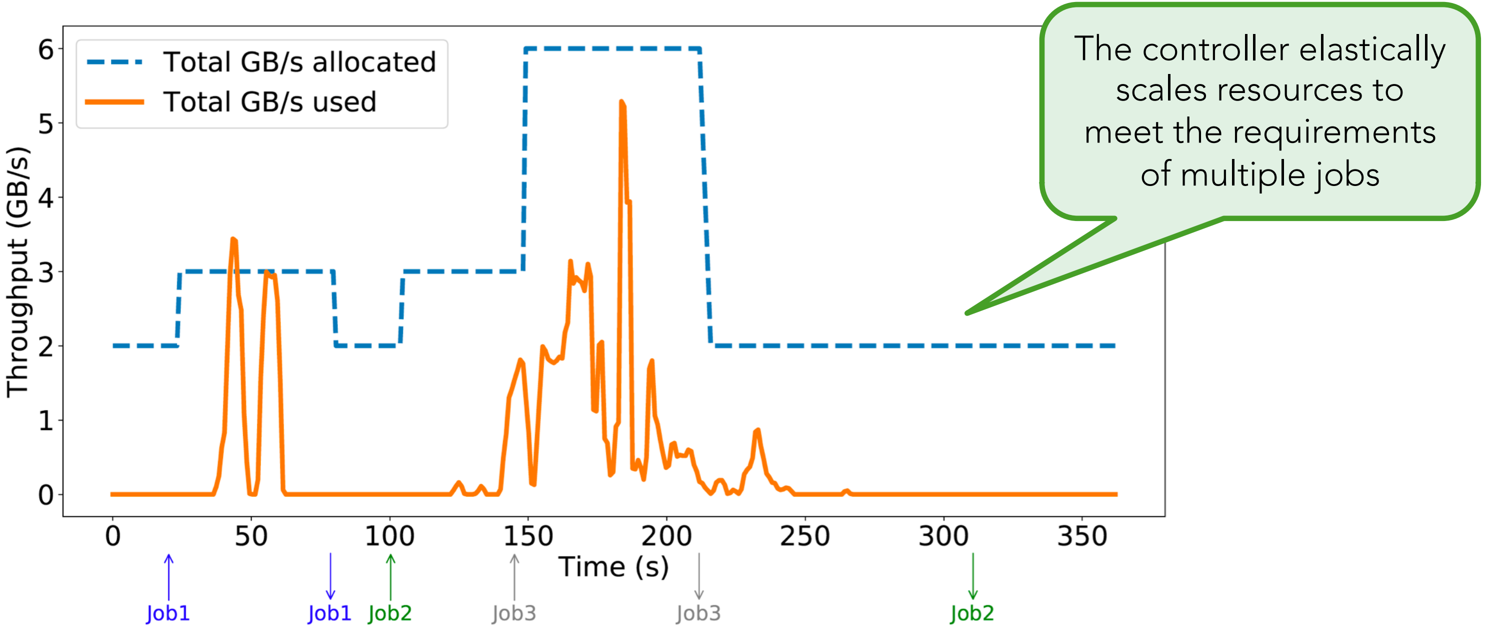


Job hints	Job1: Sort
Latency sensitive	False
Ephemeral data capacity	10 GB
Aggregate throughput	3 GB/s

Autoscaling the Pocket Cluster



Job hints	Job1: Sort	Job2: Video analytics	Job3: Sort
Latency sensitive	False	False	False
Ephemeral data capacity	10 GB	6 GB	10 GB
Aggregate throughput	3 GB/s	2.5 GB/s	3 GB/s

Conclusion

- Pocket is a distributed ephemeral storage system that:
  - Leverages multiple storage technologies
  - Rightsizes resource allocations for applications
  - Autoscales storage cluster resources based on usage
- We designed Pocket for ephemeral data sharing in serverless analytics. More generally, Pocket is an elastic, distributed `/tmp`.

www.github.com/stanford-mast/pocket

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