Understanding Ephemeral Storage for Serverless Analytics

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Introduction

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- This makes serverless computing appealing for *interactive analytics*
- **The challenge:** tasks ('lambdas') need an efficient way to communicate intermediate results

ephemeral data

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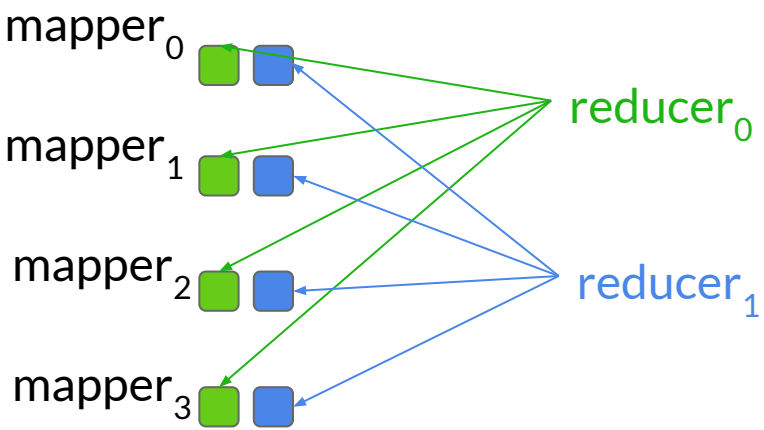

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- Direct communication between lambdas is difficult:
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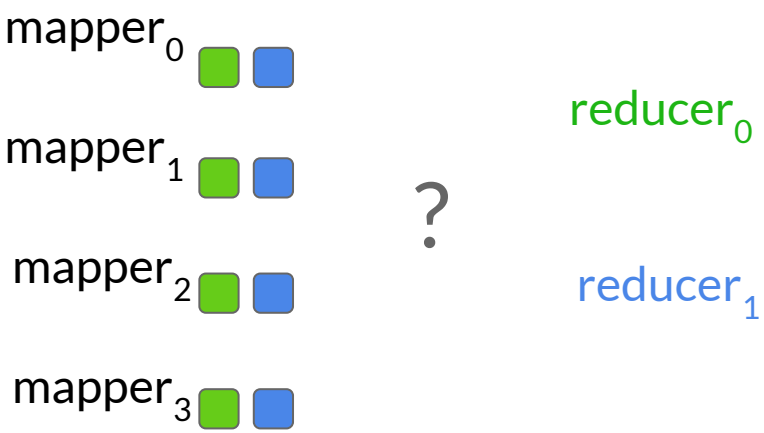

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$mapper_1$

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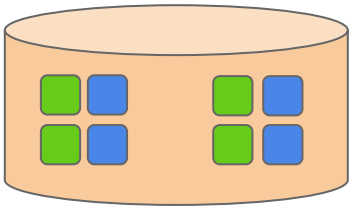
$reducer_0$

$reducer_1$



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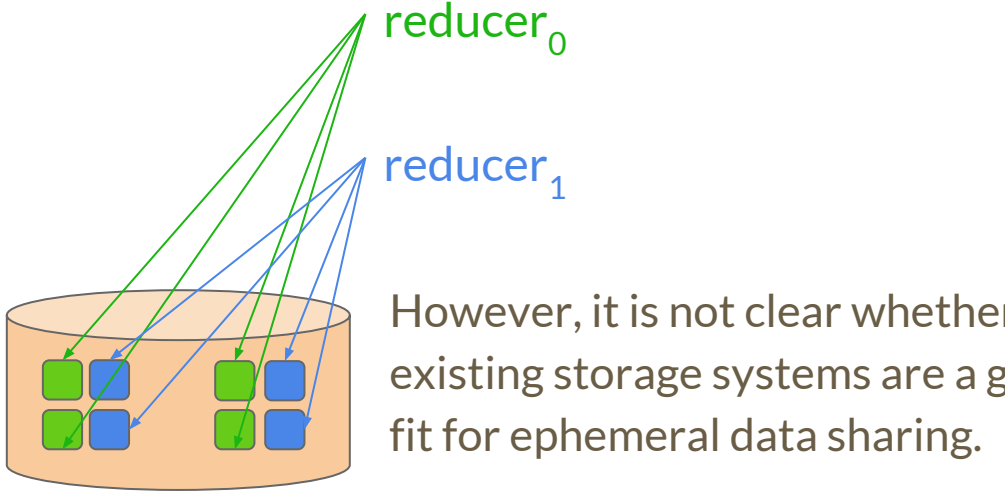


However, it is not clear whether existing storage systems are a good fit for ephemeral data sharing.

Questions:

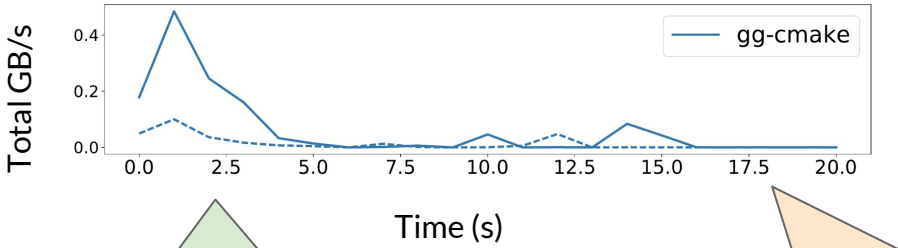
1. What are the ephemeral I/O characteristics of serverless analytics applications?
2. How do applications perform using existing systems (e.g., S3, Redis) for ephemeral I/O?
3. What storage media (DRAM, Flash, HDD) satisfies I/O requirements at the lowest cost?

1. Application Ephemeral I/O Patterns

Application Type

Distributed Compilation

Ephemeral I/O Throughput: Write (dotted), Read (solid)



Ephemeral Data Capacity

0.85 GB

High throughput and IOPS due to high parallelism: lambdas each compile independent files

Archiving and linking lambdas are serialized as they depend on previous lambdas → low parallelism, low I/O rate

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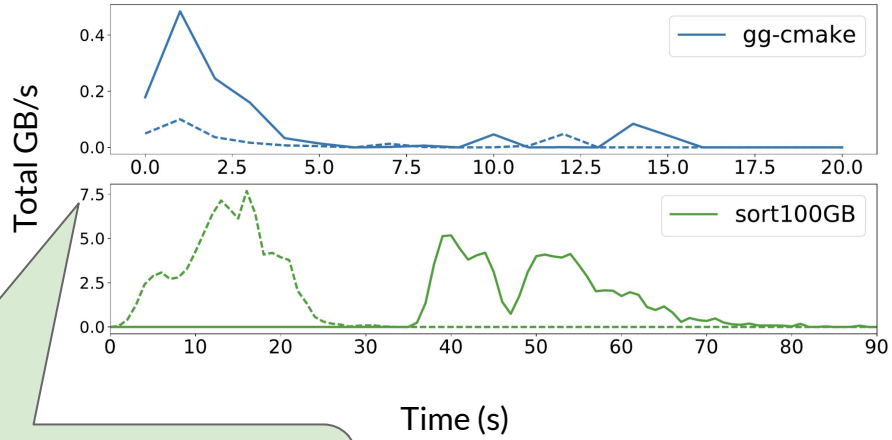
MapReduce

100 GB



High throughput due to high I/O intensity and parallelism (up to 7.5 GB/s with 500 concurrent lambdas)

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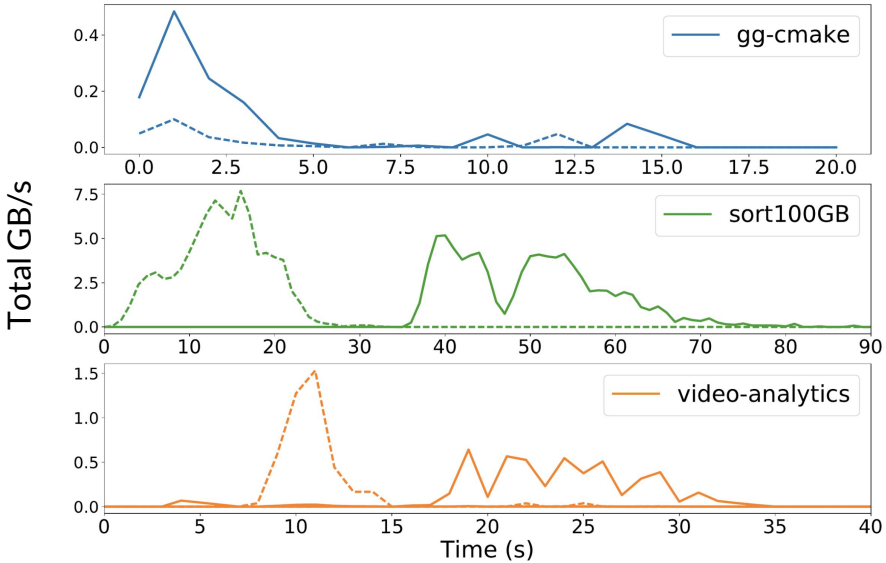
Distributed Compilation		0.85 GB
MapReduce		100 GB
Video Analytics		6 GB

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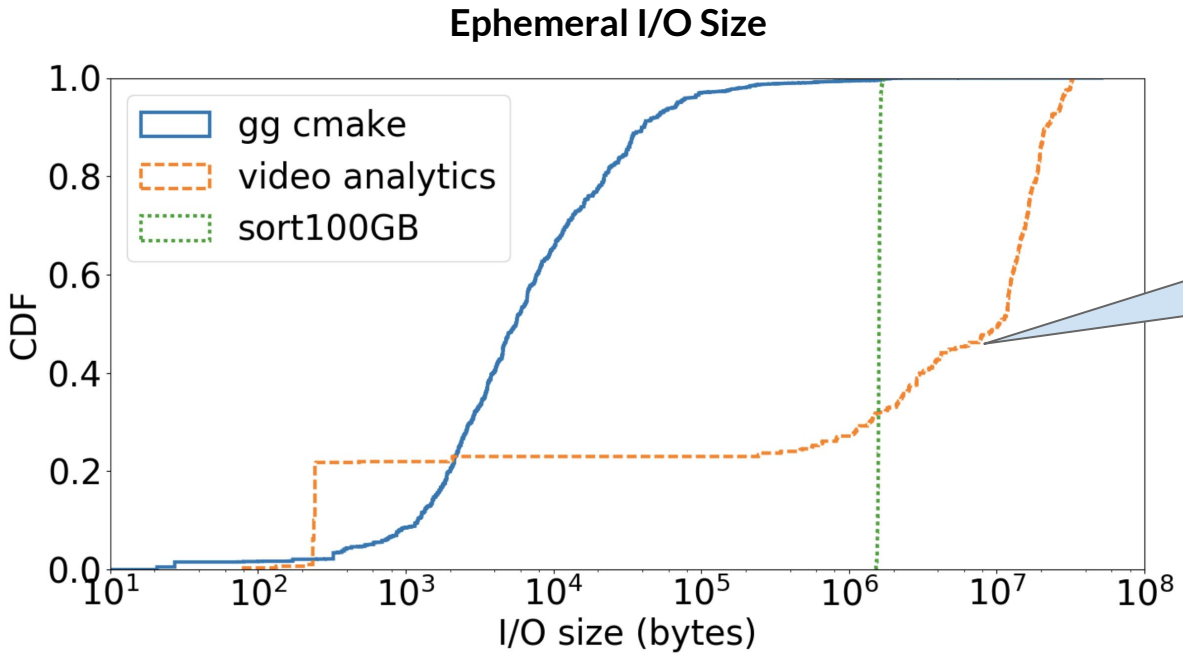

Wide range of I/O sizes (bytes to 100s of MBs)

Thus, an ephemeral storage system should support high throughput ***and*** low latency.

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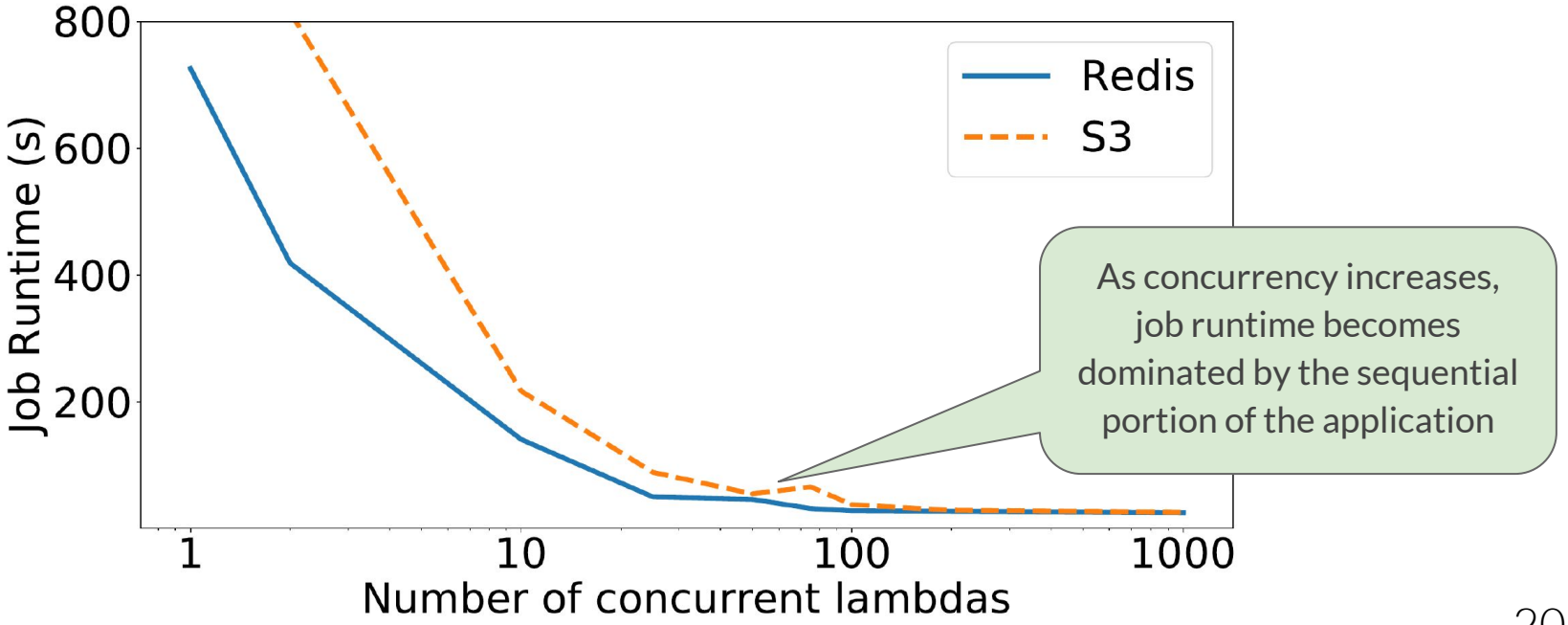
3. **Distributed Flash-based data store (e.g. Crail-ReFlex)**
   - Use Flash for high bandwidth at lower cost
   - Manually select and scale storage instances

Latency sensitivity

- Distributed compilation job shows some sensitivity to latency due to small I/Os



The impact of application parallelism

Distributed compilation (gg-cmake) with up to 650 concurrent lambdas using S3

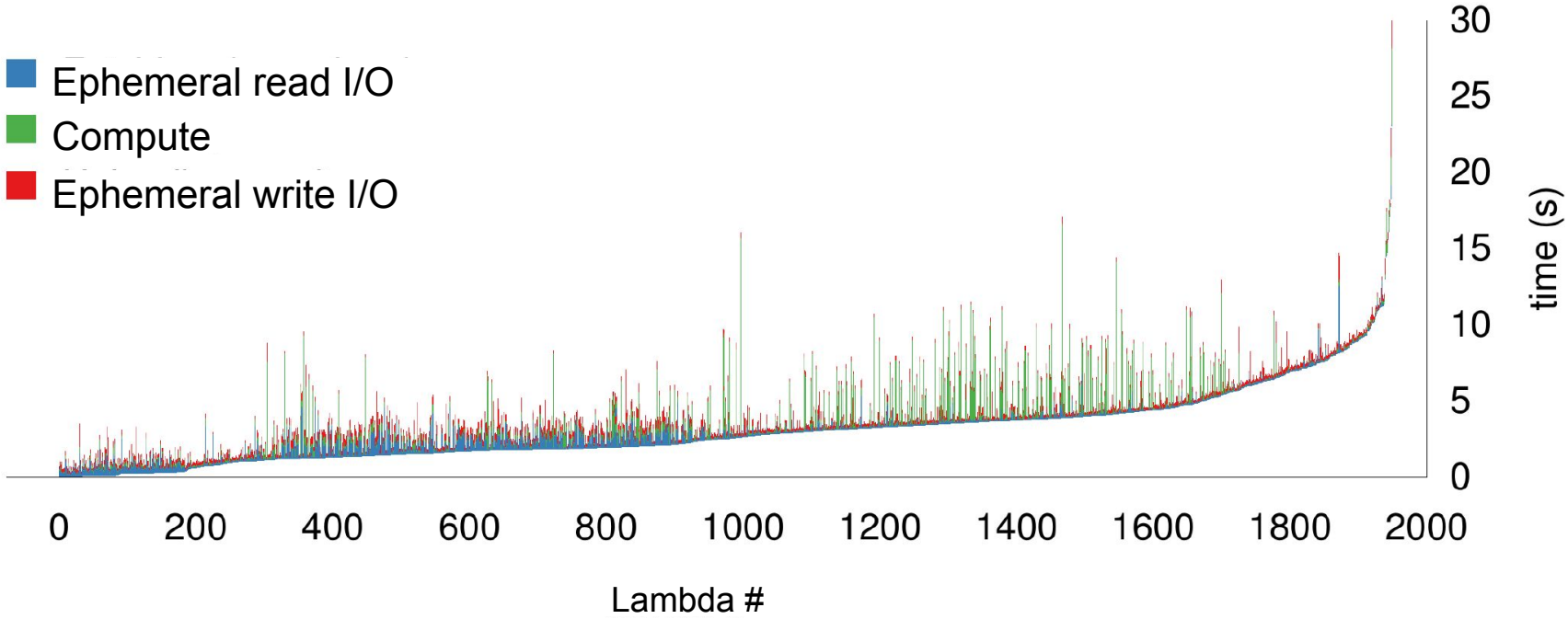


Figure based on Fig. 6 in "A thunk to remember: make -j1000 (and other jobs) on functions-as-a-service infrastructure (preprint)." Fouladi, S., et al.

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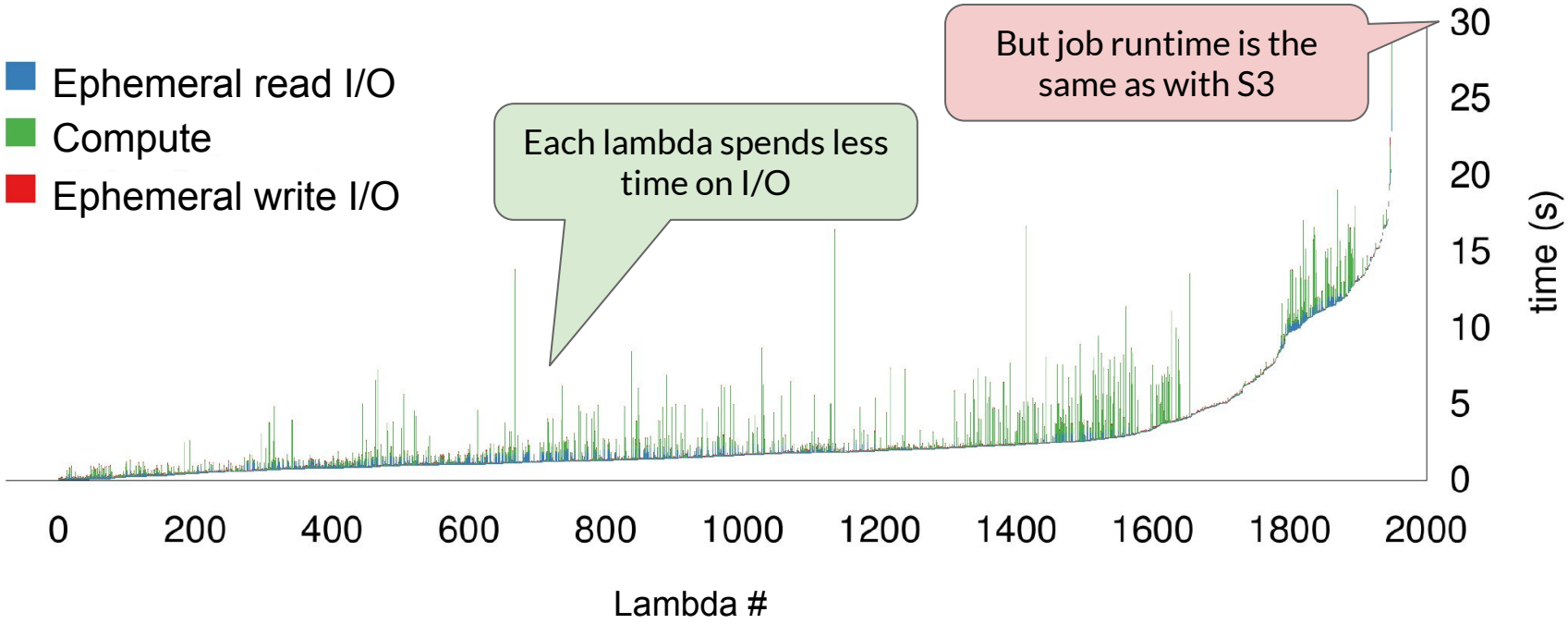

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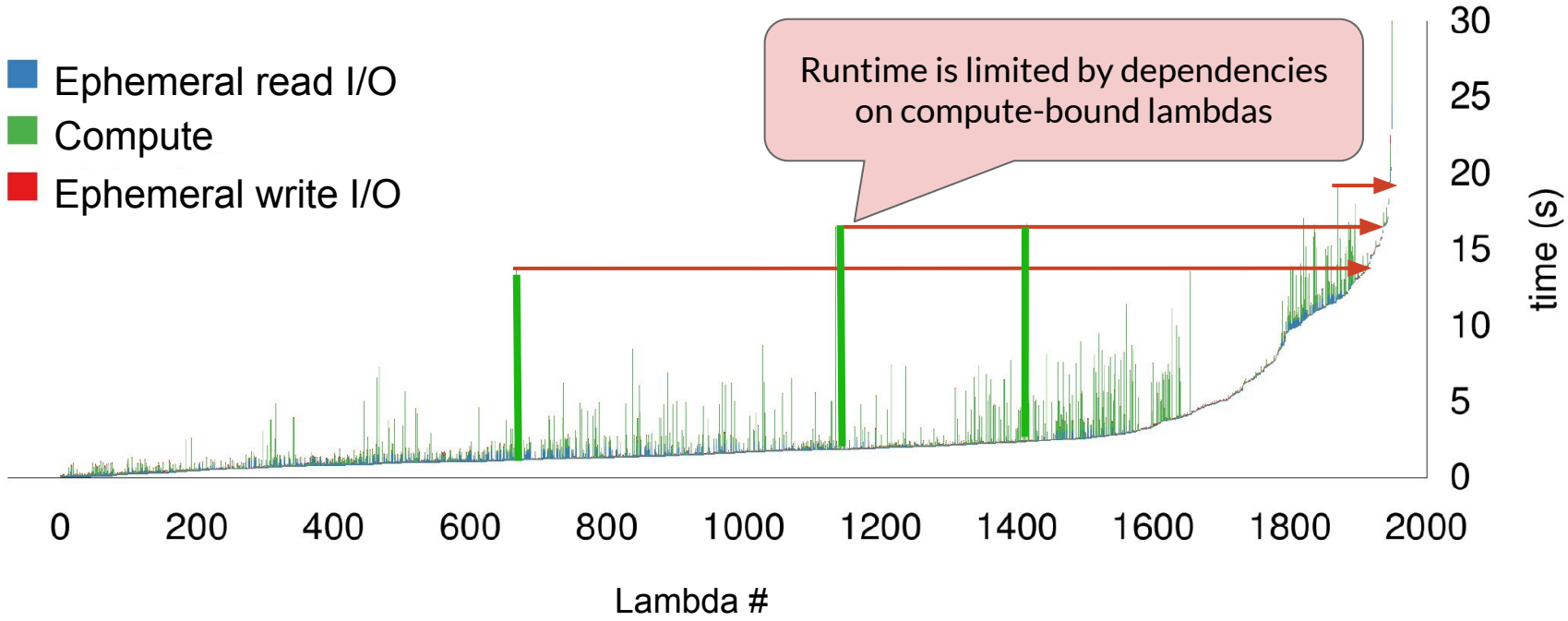

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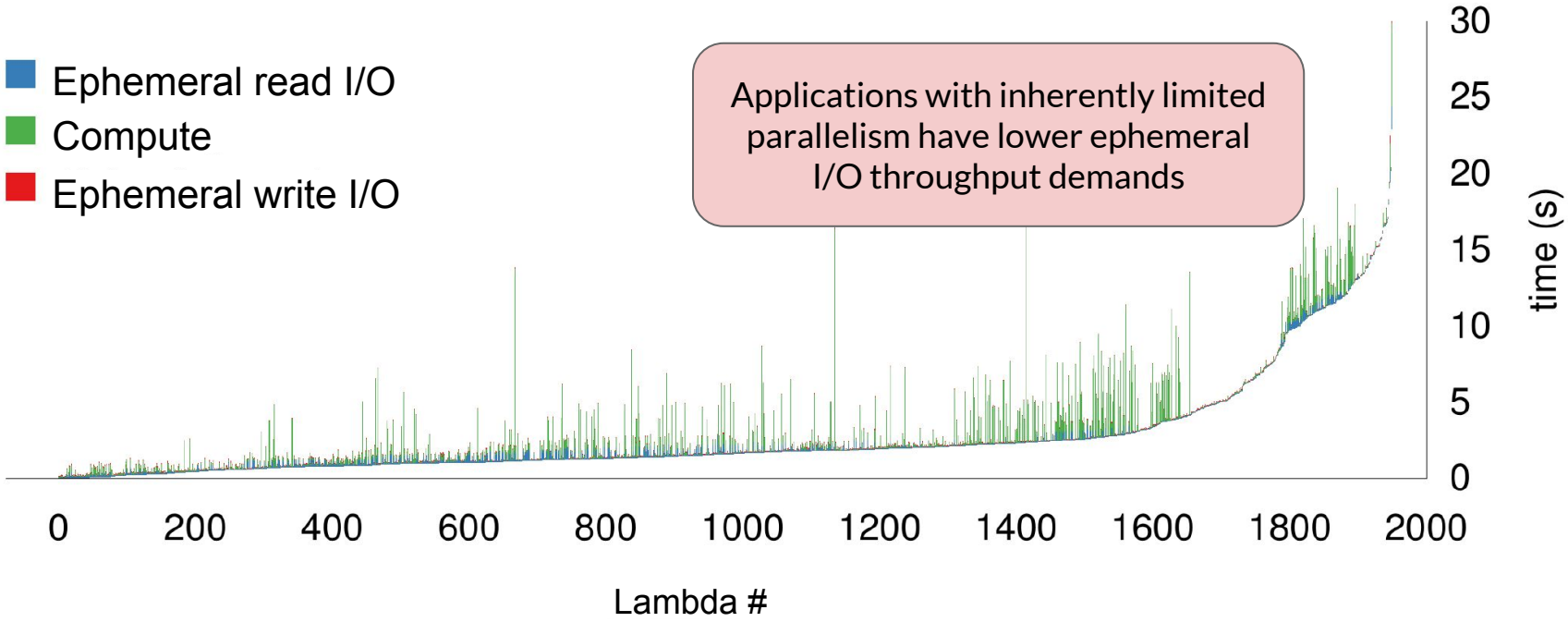

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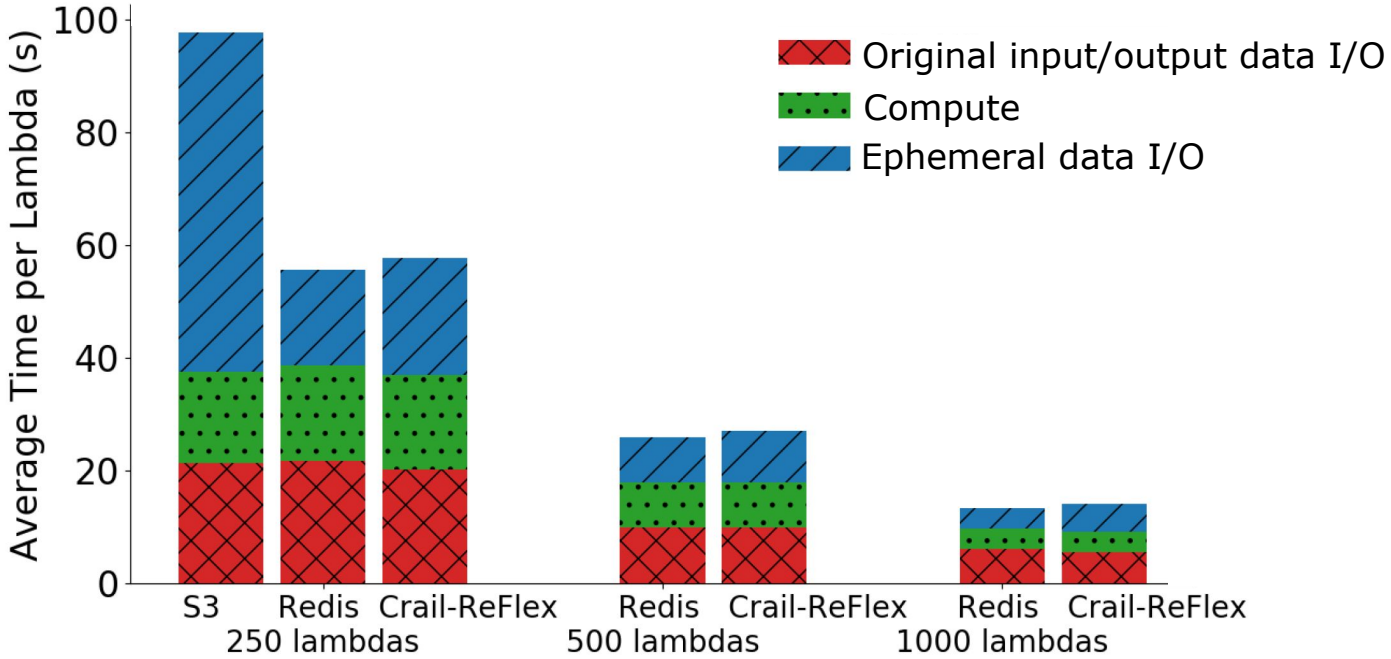
High I/O intensity

MapReduce sort (100 GB) demands high throughput



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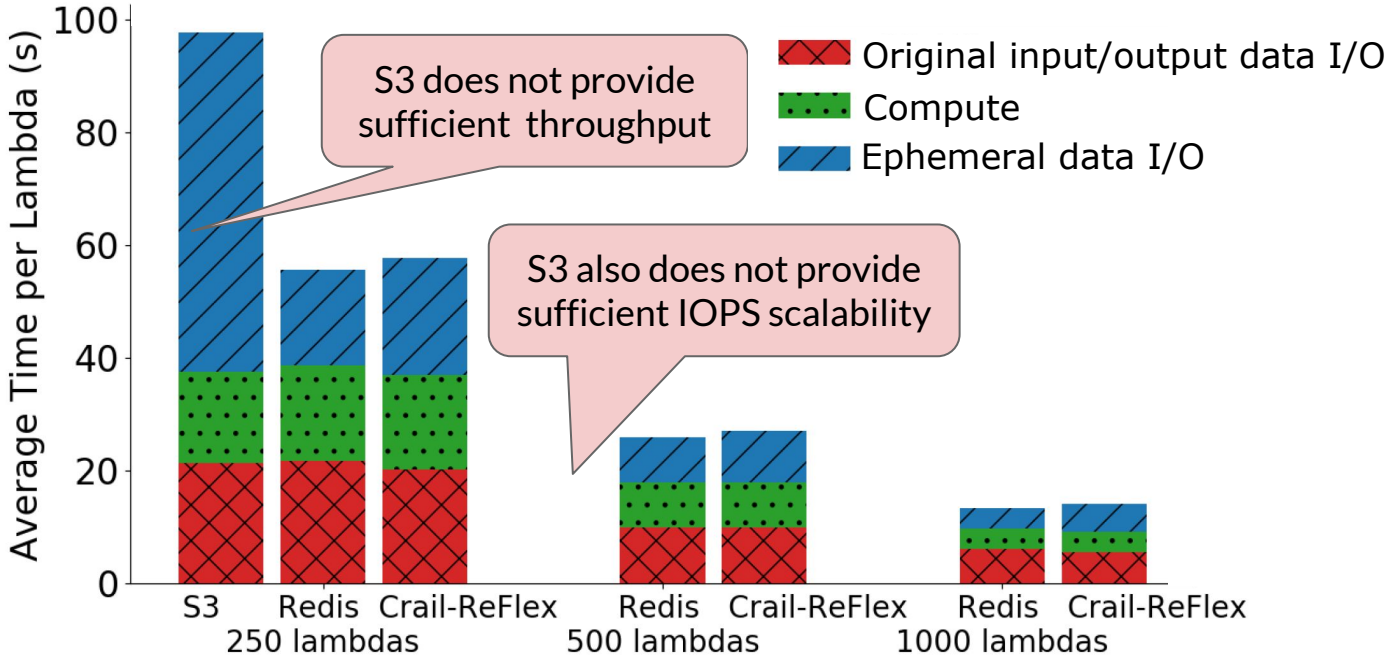

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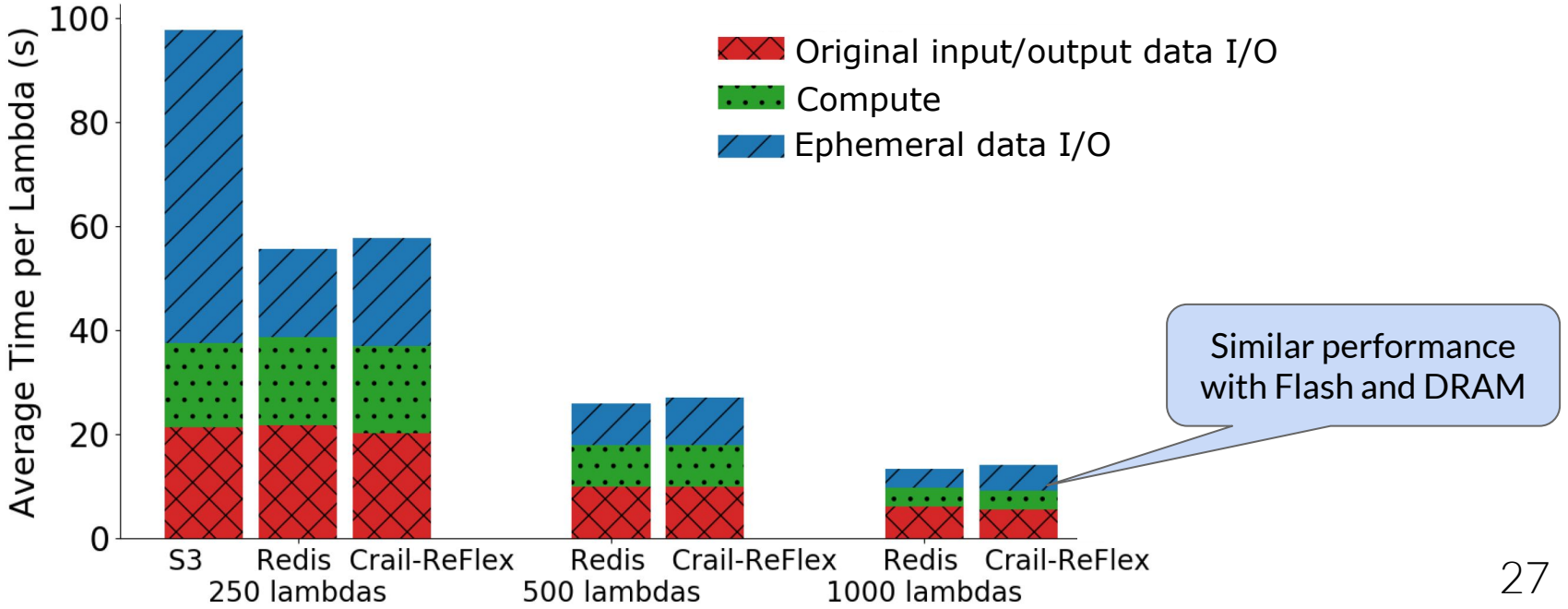
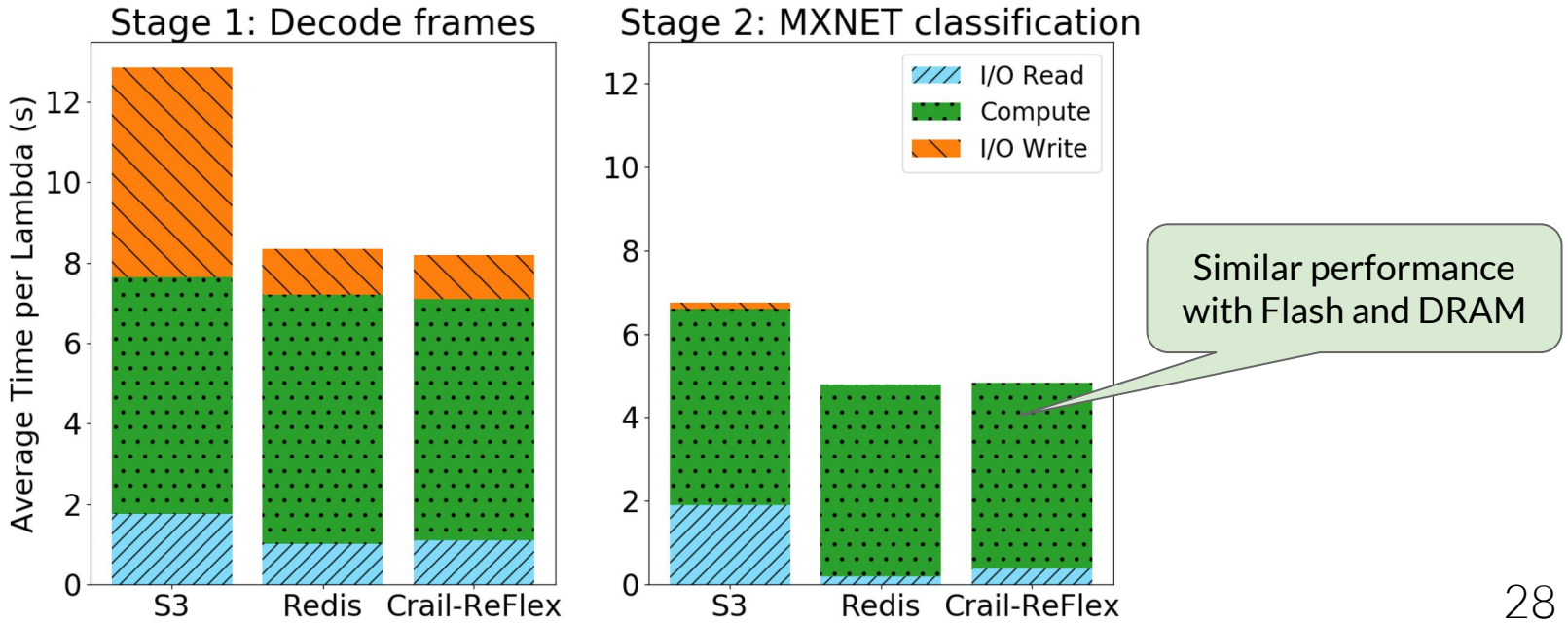


High I/O and compute intensity

Video analytics has both high I/O and compute intensity



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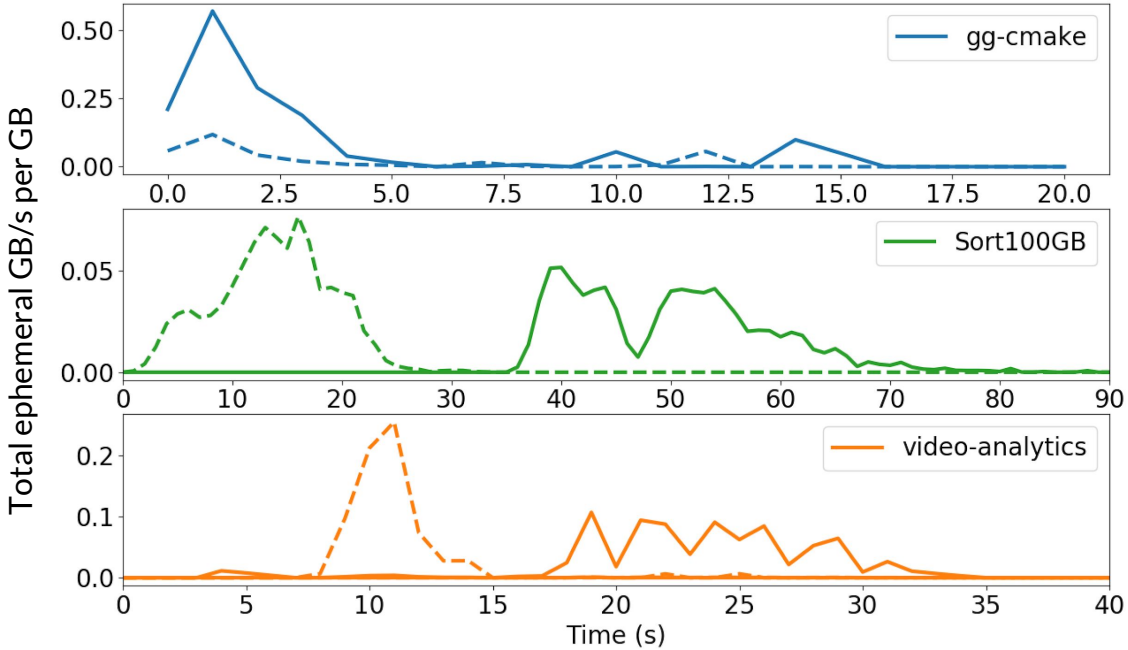
- Compare throughput:capacity ratios of DRAM, Flash, HDD



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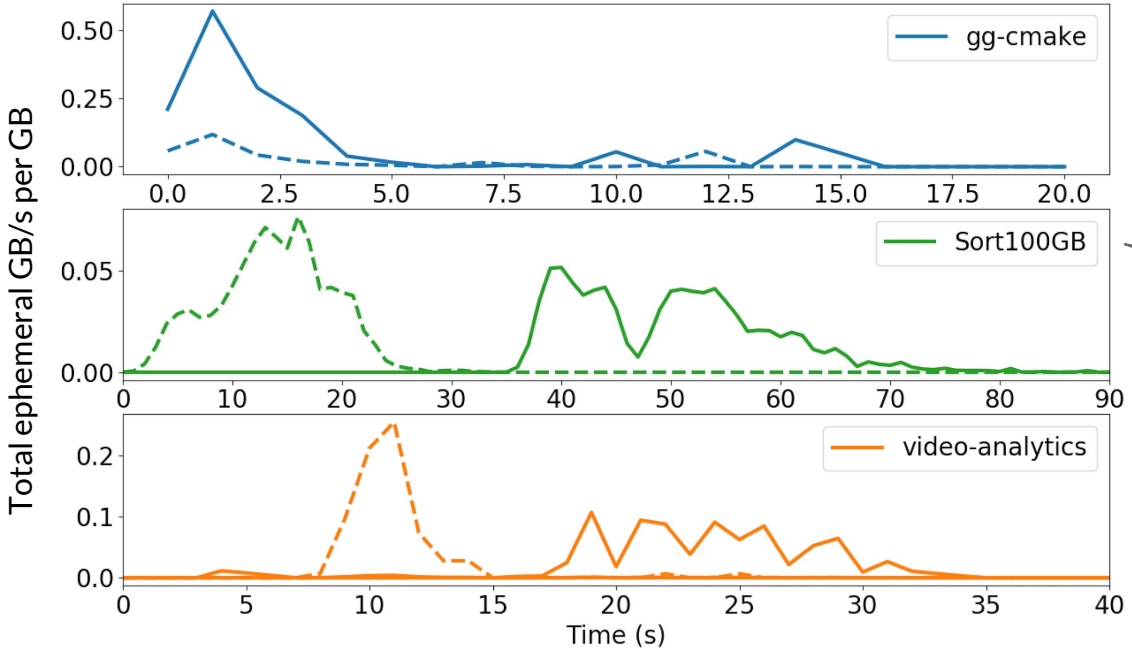

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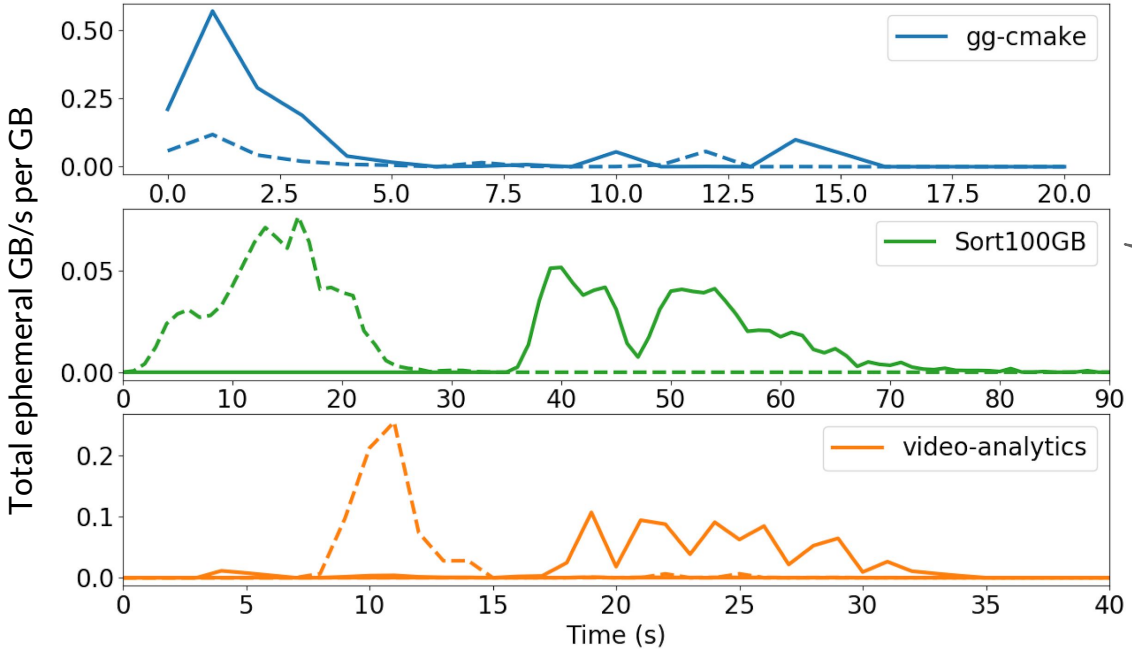

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Using Flash vs. DRAM, jobs achieve similar performance at lower cost per bit

Putting it all together...

- Ephemeral storage wishlist for serverless analytics:
  - ★ **High throughput and IOPS**
  - ★ **Low latency**, particularly important for small requests
  - ★ **Fine-grain, elastic scaling** to adapt to elastic application load
  - ★ **Automatic rightsizing** of resource allocations
  - ★ **Low cost**, pay-what-you-use
- Existing systems provide some but not all of these properties

Conclusion

- Our analysis motivates the design of an ephemeral storage service that supports automatic, fine-grain storage capacity and throughput allocation
- Ephemeral I/O requirements depend on a job's latency sensitivity, inherent parallelism and its I/O vs. compute intensity
- Flash is an appealing storage media for ephemeral I/O performance-cost requirements