Evaluation of Network File System as a Shared Data Storage in Serverless Computing

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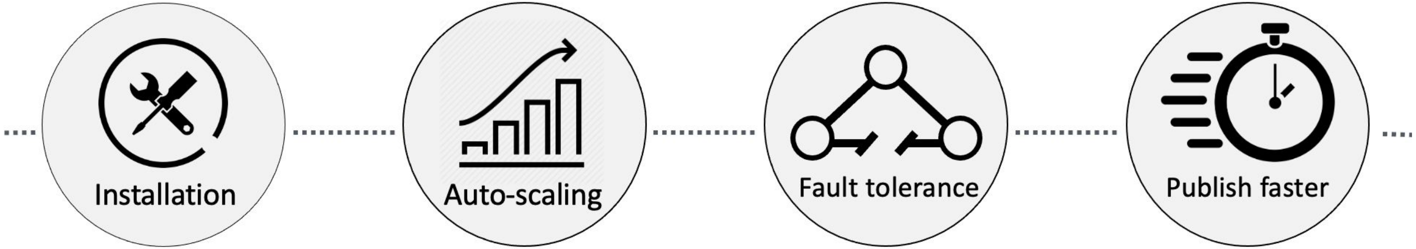
Serverless Computing

A software architecture model:
Cloud vendors operate servers and **dynamically manage computing resource allocations**

Role

- Developers: Just implement their workload as a function run-time.
- Cloud Vendor: Managing server considering scalability and reliability.



Function-as-a-Service (FaaS)

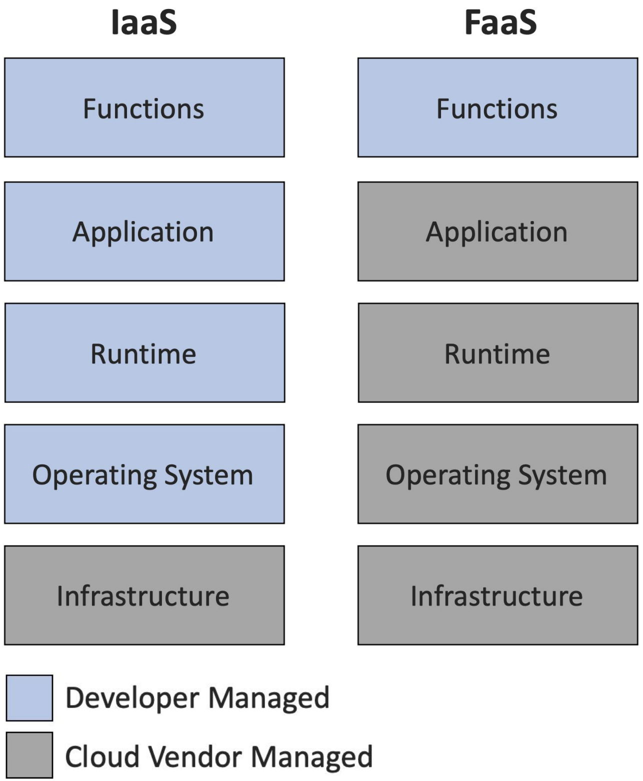
The core component of serverless computing

Developers just register function in cloud

- Python, Go, C, Javascript, Java

Characteristics

- Application composed multiple functions
- Triggered by event
- Pay-as-You-go
- Fully-managed

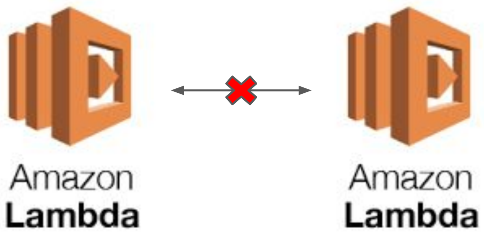


Challenges of Serverless Computing

Disadvantage of Serverless Computing

- Cold start issue causing performance variation
- No specialized hardware support

- No support **Peer-to-peer**(P2P) communication between function run-time



To overcome the limitation of P2P communication

- easy way is using **storage**

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Major Contributions

Qualitative comparison of various cloud storage services
as intermediate FaaS storage

Quantitative evaluation of NFS as a FaaS ephemeral storage service

Types of Storages for Serverless Computing

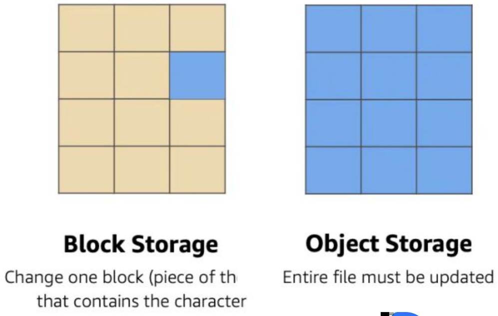
Object storage

- Cheap & slow
  disk-based object storage services (AWS S3).
- Expensive & fast
  RAM-based caching services (AWS Redis).
- Demerit: only **entire file** should be uploaded or downloaded.

Block storage

- AWS EFS, EBS
- **No support** for P2P communication
  in serverless computing
- Merit: **byte-level file access** (data-intensive applications)

Storage Type	Speed	Price
Object (S3)	Slow	$
Caching (Redis)	Fast	$$$



Using EFS for AWS Lambda

Amazon Elastic File System: Network file system(NFS) supported by AWS

AWS Compute Blog

Using Amazon EFS for AWS Lambda in your serverless applications

by James Beswick | on 18 JUN 2020 | in Amazon EC2, Amazon Elastic File System (EFS), Amazon VPC, AWS Cloud9, AWS Lambda, AWS Serverless Application Model, Serverless, Technical How-To | Permalink | Comments | Share

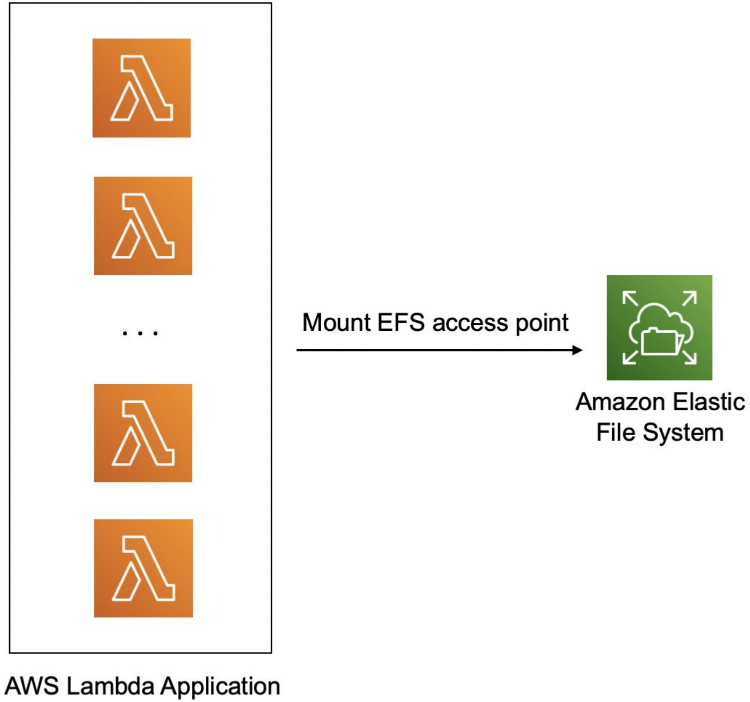
Serverless applications are event-driven, using ephemeral compute functions to integrate services and transform data. While AWS Lambda includes a 512-MB temporary file system for your code, this is an ephemeral scratch resource not intended for durable storage.

Amazon Elastic File System(EFS)

Characteristics of EFS

- Fully-managed
- **POSIX file system APIs**
  (similar local storage disk)

- Two throughput modes
  - Bursting
    : scales with consumed storage size
  - Provisioned
    : purchase additional throughput



Characteristics of NFS as a cloud storage

Network File System(NFS)

- Faster than Object Storage
- Cheaper than Object Caching Storage
- Dataset stored permanently
- Access files in byte-level

Storage Type	Speed	Price	Access	Persistence
Object (S3)	Slow	$	Object	Permanent
Caching (Redis)	Fast	$$$	Object	Permanent
Local disk	Fast	0	Block	Temporary
NFS (EFS)	**Fast**	**$$**	**Block**	**Permanent**

Experiment with EFS

Goal: Understand performance characteristics of NFS as a FaaS storage service

Environment

Function

- AWS Lambda: Python 3.6, boto3

Storage

- Lambda Layer(maximally available size: 250MB)
- AWS S3
- Amazon EFS: provisioned mode - throughput: 100MB/S

Dataset

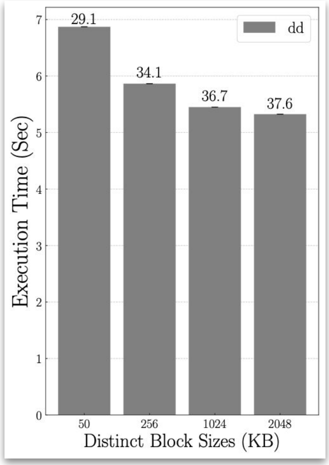
- Target File: dummy data - size: 200MB

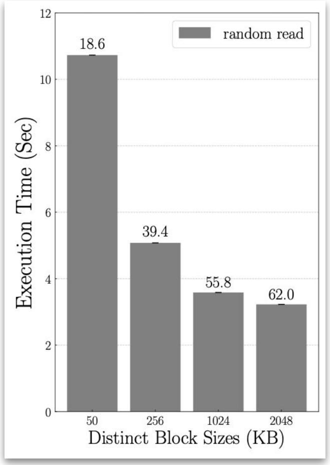
Impact of Block Sizes for EFS

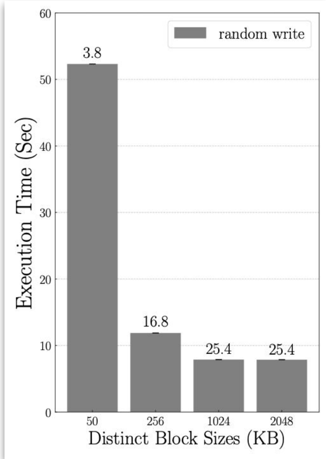
Block sizes under evaluation: 50KB, 256KB, 1MB, 2MB

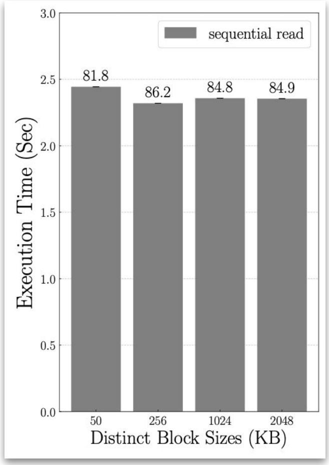
Single function run-time does not fully utilize available bandwidth (100MB/S)

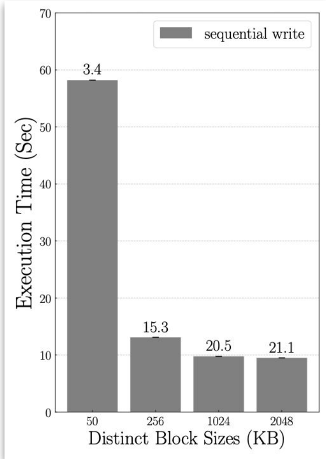
- dd (37.6 MB/S), random read (62MB/S), random write (25.4 MB/S), sequential read (84.9 MB/S), Sequential write (21.1 MB/S)







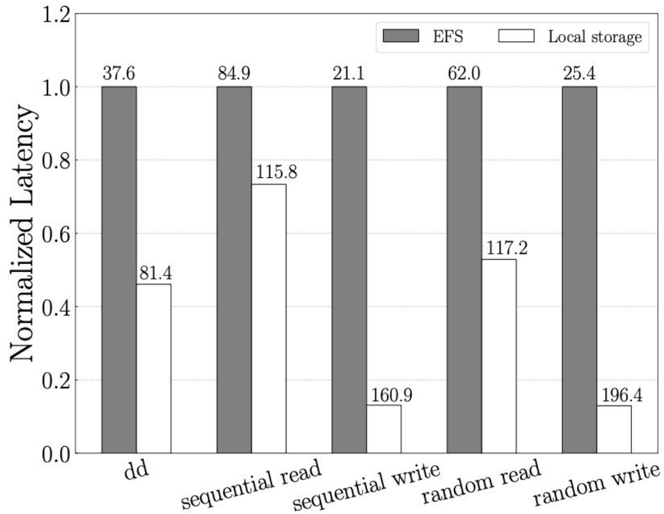




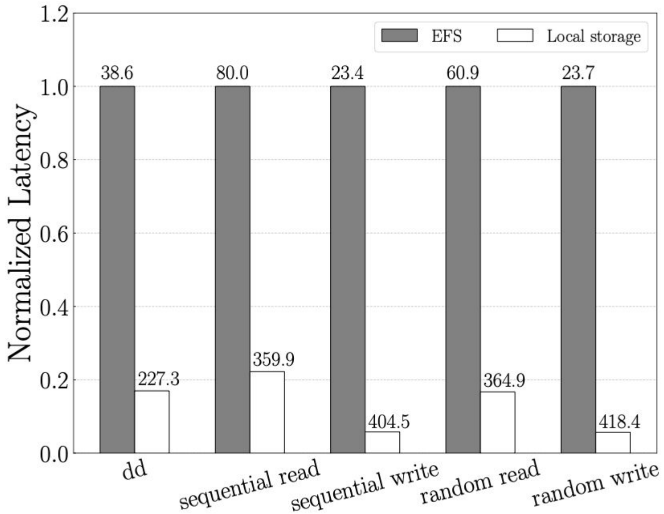
Comparing NFS with a Local Storage

Performance impact from different Lambda memory (512MB → 2GB)

- Local storage : 2~3 times more throughput achieved
- **EFS: no difference**



Lambda RAM 512MB



Lambda RAM 2G

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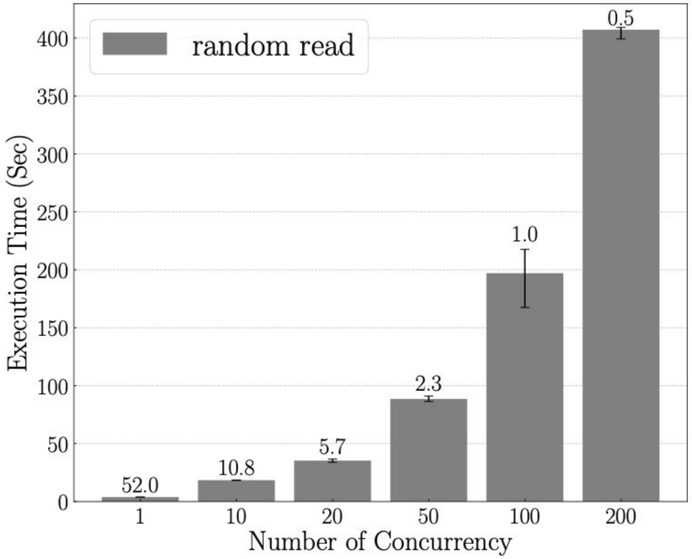
Evaluation of scalability of EFS

Multiple function request simultaneously

- Representation of workload: random read
- Lambda: 512MB, Block Size: 2MB

- Inverse proportion increasing requests and function bandwidth
- The latency increases linearly with respect to the concurrent access



Total Bandwidth(100MB/S) = Number of Concurrent * Each Function Bandwidth

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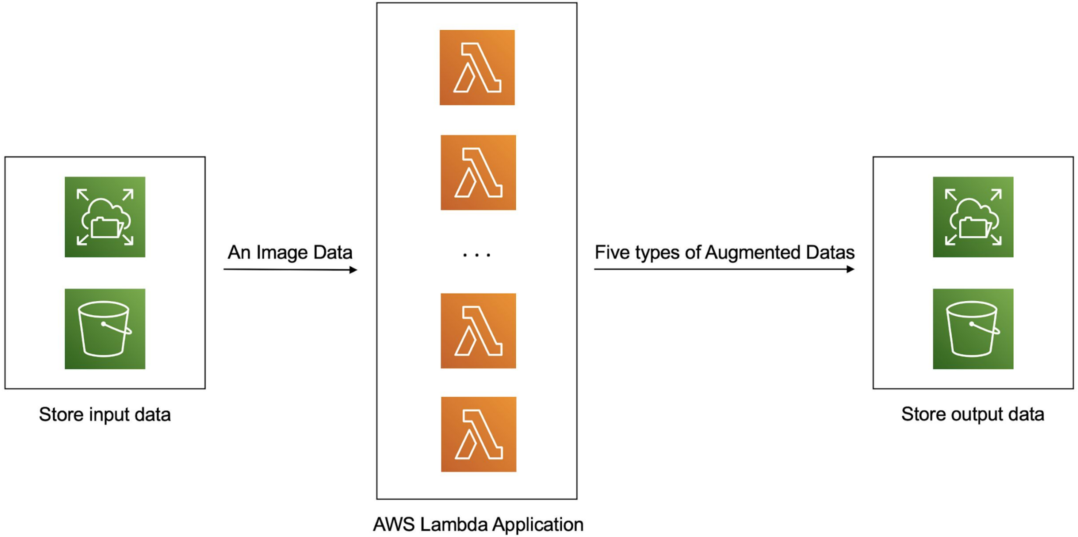
Comparing NFS with an Object Storage

Performed Image augmentation tasks in python pillow library

5 types of Image Augmentation

- flip left-right
- flip top-bottom
- grayscale
- rotate 90 degrees
- rotate 180 degrees

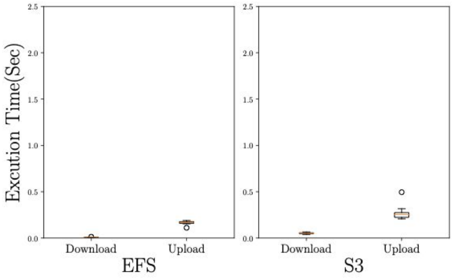


Number of Upload tasks = Number of Download tasks * **5**

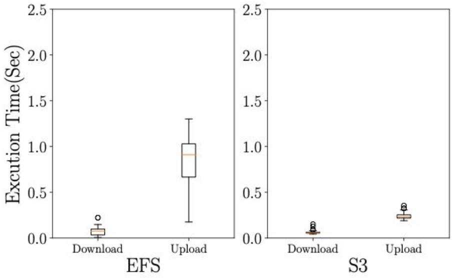
Comparing NFS with an Object Storage

Comparing image upload and download latency of EFS and S3 with a different number of parallel executions

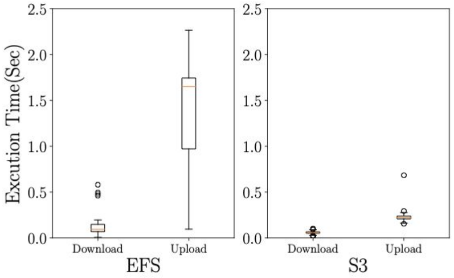
- EFS show severe degradation as parallel requests increase



10 input images



50 input images



100 input images

The Coefficient of variation(CoV)

- the ratio of the standard deviation to the average.

Number Of Images	EFS	S3
10	0.13	0.31
50	0.29	0.14
100	0.41	0.22

Cov of upload task

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Conclusion and future work

Quantitative comparison of various cloud storage services for ephemeral storage for FaaS

Qualitative evaluation of EFS under various scenarios

- **Limited single function bandwidths** comparing to a local storage
- Bandwidths sharing among **parallel function invocations**
- Noticeable performance degradation when **multiple function run-times access**

Future work

- Discover new application scenarios using EFS with Lambda, such as MapReduce
- Understanding consistency performance of EFS with Lambda

Q&A

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