**CLOUD COMPUTING APPLICATIONS**

Cloud Storage: Object Storage

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Cloud Object Storage

- As we have seen, Distributed File Systems are not easy
  - Considerable overhead, complexity, cost
  - Main reason: maintaining consistency while providing transparency

- CAP: Consistency, Availability, Partition Tolerance

- Transparency: "invisible" to client programs, which "see" a system which is similar to a local file system.
  - Behind the scenes, the distributed file system handles locating files, transporting data, and potentially providing other features listed below
  - While transparency may seem trivial, these semantics can incur a significant performance penalty at scale despite not being strictly necessary
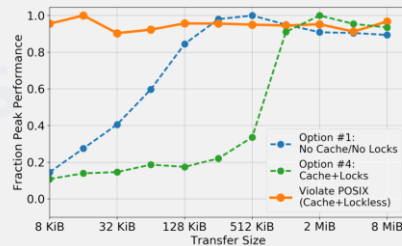
Internet Scale Storage: Breaking the Chains of Transparency and Consistency

- What if we want to scale to "unlimited Storage"?
- Solution: Stop trying to have all 3 components of CAP
  - Availability: Important to keep, otherwise customer data may be unavailable
  - Partition Tolerance: Networks do fail, cloud providers have to be resilient
  - Consistency: Can be scarified
- The typical BLOB storage by a cloud provider can scale "infinitely" by being "eventually consistent"
- In addition, they typically are not POSIX compliant
- The access model is through REST APIs
  - GET, PUT, DELETE
- Examples:
  - AWS S3
  - OpenStack Swift

AWS S3 Consistency Model

- Objects have a URI, and are accessible by REST API calls
  - https://cloudApplications.s3.us-west-2.amazonaws.com/photos/picture1.jpg
- If you PUT to an existing key, a subsequent read might return the old data or the updated data, but it never returns corrupted or partial data.
- For Availability, data will be replicated across AWS datacenters (Availability Zones)
  - If a PUT request is successful, your data is safely stored. But temporarily:
    - A process writes a new object to Amazon S3 and immediately lists keys within its bucket. Until the change is fully propagated, the object might not appear in the list.
    - A process replaces an existing object and immediately tries to read it. Until the change is fully propagated, Amazon S3 might return the previous data.
    - A process deletes an existing object and immediately tries to read it. Until the deletion is fully propagated, Amazon S3 might return the deleted data.
    - A process deletes an existing object and immediately lists keys within its bucket. Until the deletion is fully propagated, Amazon S3 might list the deleted object.
  - Amazon S3 does not currently support object locking. If two PUT requests are simultaneously made to the same key, the request with the latest timestamp wins
  - Updates are key-based. There is no way to make atomic updates across keys.

Cloud Object Storage

- By relaxing the consistency model, building the distributed storage system becomes much simpler

- The Storage costs are significantly cheaper

- Bandwidth can be quite high
  - Up to 25 GB/s

- Unlike the previous models (Block Storage, Managed File System), data can be accessible from outside the cloud
  - Your mobile app customers all over the world
  - The small number of computers you personally own

AWS S3 tiers comparison

	S3 Standard	S3 Intelligent-Tiering*	S3 Standard-IA	S3 One Zone-IA†	S3 Glacier	S3 Glacier Deep Archive
Designed for durability	99.999999999% (11 9's)	99.999999999% (11 9's)	99.999999999% (11 9's)	99.999999999% (11 9's)	99.999999999% (11 9's)	99.999999999% (11 9's)
Designed for availability	99.99%	99.9%	99.9%	99.5%	99.99%	99.99%
Availability SLA	99.9%	99%	99%	99%	99.9%	99.9%
Availability Zones	≥3	≥3	≥3	1	≥3	≥3
Minimum capacity charge per object	N/A	N/A	128KB	128KB	40KB	40KB
Minimum storage duration charge	N/A	30 days	30 days	30 days	90 days	180 days
Retrieval fee	N/A	N/A	per GB retrieved	per GB retrieved	per GB retrieved	per GB retrieved
First byte latency	milliseconds	millseconds	milliseconds	milliseconds	select minutes or hours	select hours
Storage type	Object	Object	Object	Object	Object	Object
Lifecycle transitions	Yes	Yes	Yes	Yes	Yes	Yes

Service	Cost per 1TB / month
AWS EFS	$300
AWS FSx Lustre	$290
EBS gp2	$100
AWS EFS infrequent access	$25
S3 standard	**$23**
S3 infrequent	**$13**
S3 Glacier	$4
S3 Glacier deep archive	$1

Prices and bandwidths are a snapshot in time, might be different now

Summary

- Cloud Object Storage
- Consistency Model
- API
- Tiers