BIG DATA AND CLOUD FILE SYSTEMS

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CONTENTS

- Ceph, HIVE, Tez
- OpenStack SWIFT / Amazon S3
- Amazon EBS, Amazon Glacier
- Dropbox Cloud API

CEPH - MOTIVATION

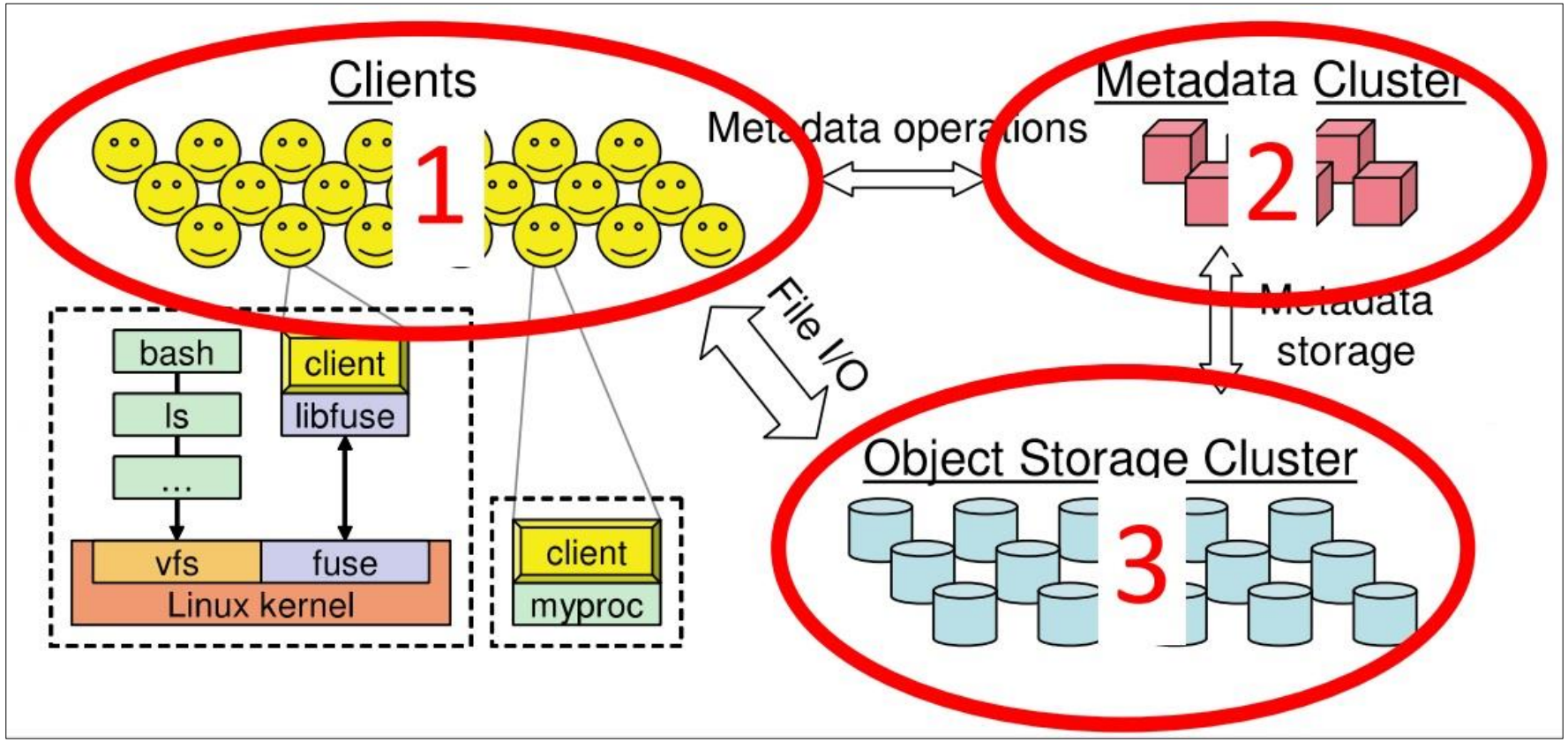
- Ceph is an emerging technology in the production-clustered environment
- designed for:
  - performance – striped data over data servers
  - reliability – no single point of failure
  - scalability – adaptable metadata cluster
  - more general than HDFS
    - smaller files
- GlusterFS has more or less similar ideas

CEPH - OVERVIEW

- MDS – Meta Data Server
- ODS – Object Data Server
- MON – Monitor
- **decoupled data and metadata**
  - I/O directly with object servers
- **dynamic distributed metadata management**
  - multiple metadata servers handling different directories (subtrees)
- **reliable autonomic distributed storage**
  - ODS's manage themselves by replicating and monitoring

CEPH - COMPONENTS

- ordered: clients, meta data, object storage



CEPH – DECOUPLING DATA AND METADATA

- increases performance by limiting interaction between clients and servers
- decoupling is common in distributed filesystems: HDFS, Lustre, Panasas, …
- in contrast to other file systems, Ceph uses a function to calculate the block locations

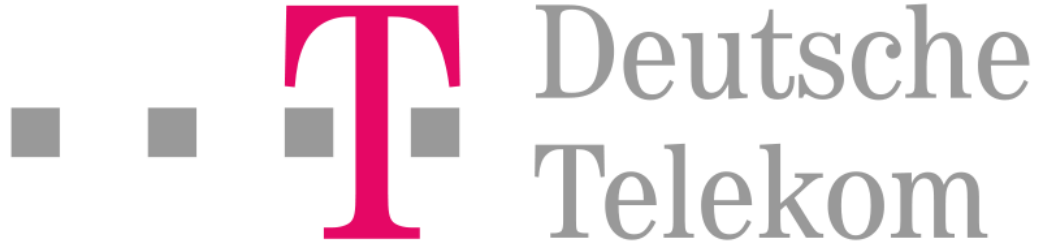
CEPH – DYNAMIC DISTRIBUTED METADATA MANAGEMENT

- metadata is split among cluster of servers
- distribution of metadata changes with the number of requests to even load among metadata servers
- metadata servers also can quickly recover from failures by taking over neighbors' data
- improves performance by leveling metadata load

CEPH – RELIABLE AUTONOMIC DISTRIBUTED STORAGE

- data storage servers act on events by themselves
- initiates replication and
- improves performance by offloading decision making to the many data servers
- improves reliability by removing central control of the cluster (single point of failure)

CEPH - USERS



HIVE– BACKGROUND

- started at Facebook
- data was collected by nightly cron jobs into Oracle DB
- “ETL” via Python
- HQL, a variant of SQL
- translates queries into MapReduce jobs
- note
  - no UPDATE or DELETE support
  - focuses primarily on the query part of SQL

HIVE - EXAMPLE

- Hive looks similar to an SQL database
- relational join on two tables:
  - table of word counts from Shakespeare collection
  - table of word counts from Homer

HIVE – EXAMPLE (2)

```
SELECT s.word, s.freq, k.freq FROM shaespeare s
JOIN homer k ON (s.word=k.word) WHERE
s.freq >= 1 AND k.freq >= 1 ORDER BY s.freq DESC LIMIT 10;
```

the	25848	62394
I	23031	8854
and	19671	38985
to	18038	13526
Of	16700	34654
A	14170	8057
You	12702	2720
My	11297	4135
In	10797	12445
Is	8882	6884

HIVE – BEHIND THE SCENES

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SELECT s.word, s.freq, k.freq FROM shakespeare s
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Abstract Syntax Tree

```
(TOK_QUERY (TOK_FROM (TOK_JOIN (TOK_TABREF shakespeare s) (TOK_TABREF homer k) (= (.
(TOK_TABLE_OR_COL s) word) (. (TOK_TABLE_OR_COL k) word)))) (TOK_INSERT (TOK_DESTINATION (TOK_DIR
TOK_TMP_FILE)) (TOK_SELECT (TOK_SELEXPR (. (TOK_TABLE_OR_COL s) word)) (TOK_SELEXPR (.
(TOK_TABLE_OR_COL s) freq)) (TOK_SELEXPR (. (TOK_TABLE_OR_COL k) freq))) (TOK_WHERE (AND (>= (.
(TOK_TABLE_OR_COL s) freq) 1) (>= (. (TOK_TABLE_OR_COL k) freq) 1))) (TOK_ORDERBY
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```

(one or more of MapReduce jobs)

HIVE - COMPONENTS

- shell: allows interactive queries
- driver: session handles, fetch, execute
- compiler: parse, plan, optimize
- execution engine
- metastore: schema, location in HDFS, etc.

HIVE - METASTORE

- Hive uses a traditional database to store its metadata:
  - A namespace containing a set of tables
  - Holds table definitions (column types, physical layout)
  - Holds partition information
- can be stored in MySQL, Oracle, and many other relational databases

TEZ- DESIGN GOALS

- **empowering end users by:**
  - expressive dataflow definition APIs
  - flexible Input-Processor-Output runtime model
  - data type agnostic
  - simplifying deployment
- **execution performance**
  - performance gains over MapReduce
  - optimal resource management
  - plan reconfiguration at runtime
  - dynamic physical data flow decisions

TEZ- INTEGRATES HIVE AND PIG

- Hive, Pig creates
  - extra MapReduce jobs when implemented with Hadoop compared with using Tez

OBJECT STORAGES – BLOB DEFINITION

A **Binary Large OBject (BLOB)** is a collection of binary data as a single entity in a database management system.

(not the 1958 sci-fi movie)

USE CASES OF OBJECT STORAGES

- store unstructured object data like text or binary data
- images
- movies
- audio, signal data
- large queue of messages
- usually accessible over the web
- example is LinkedIN data in a user page

EXAMPLES OF OBJECT STORAGES

- Microsoft Azure Blob Storage
- Ambry used by LinkedIN
- Facebook’s Warm Blob Storage System
- Amazon Simple Storage Service (S3)
- Apache Open Stack Blob Service (SWIFT)

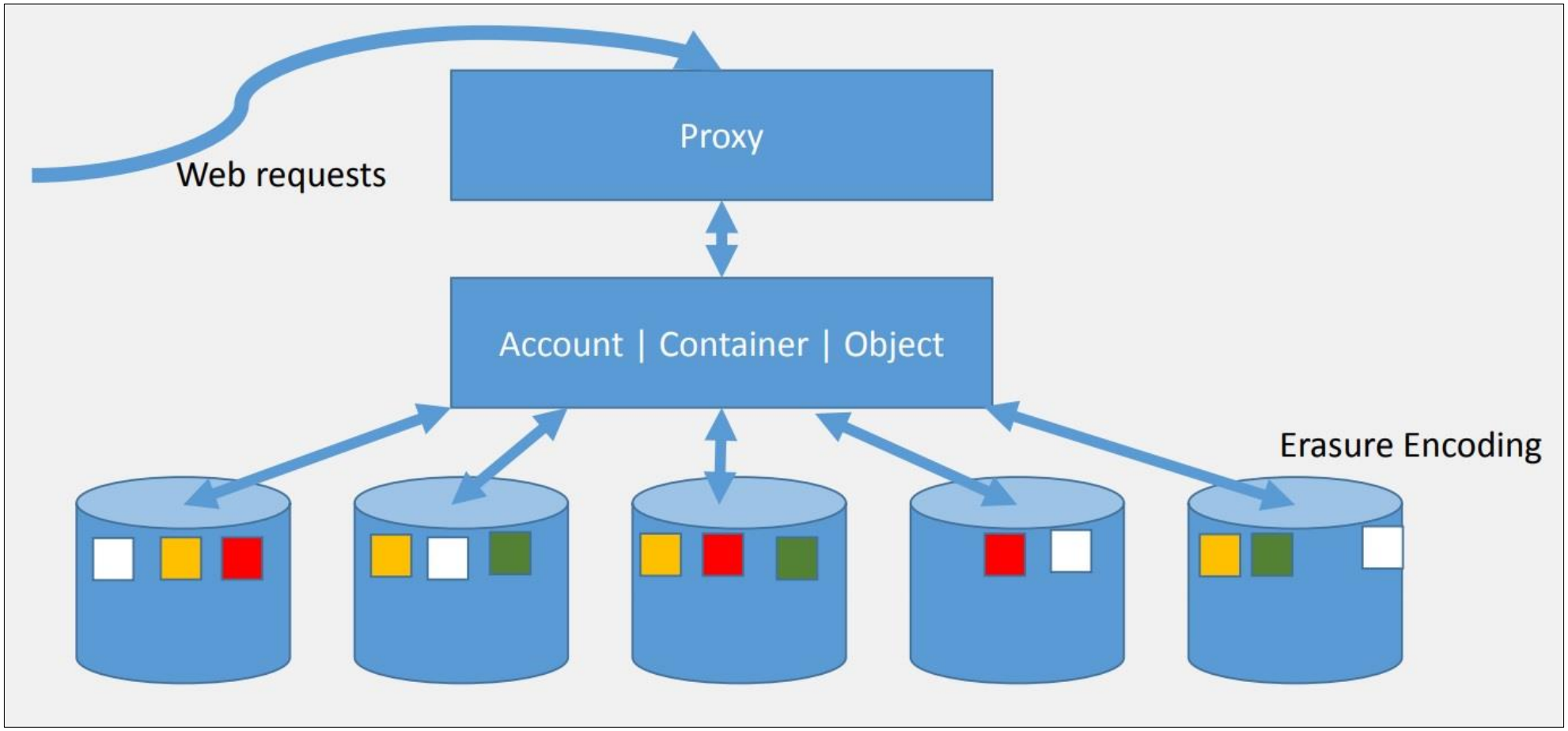
WHY DO WE NEED OBJECT STORAGES?

- data growth approx. 50% a year
- 50%-70% data is unstructured or archival
- RESTful API (HTTP)
- high availability (no single point of failure)
- agile data centers
- open source
- multi-region, geographic distribution of data
- storage policies
- erasure coding

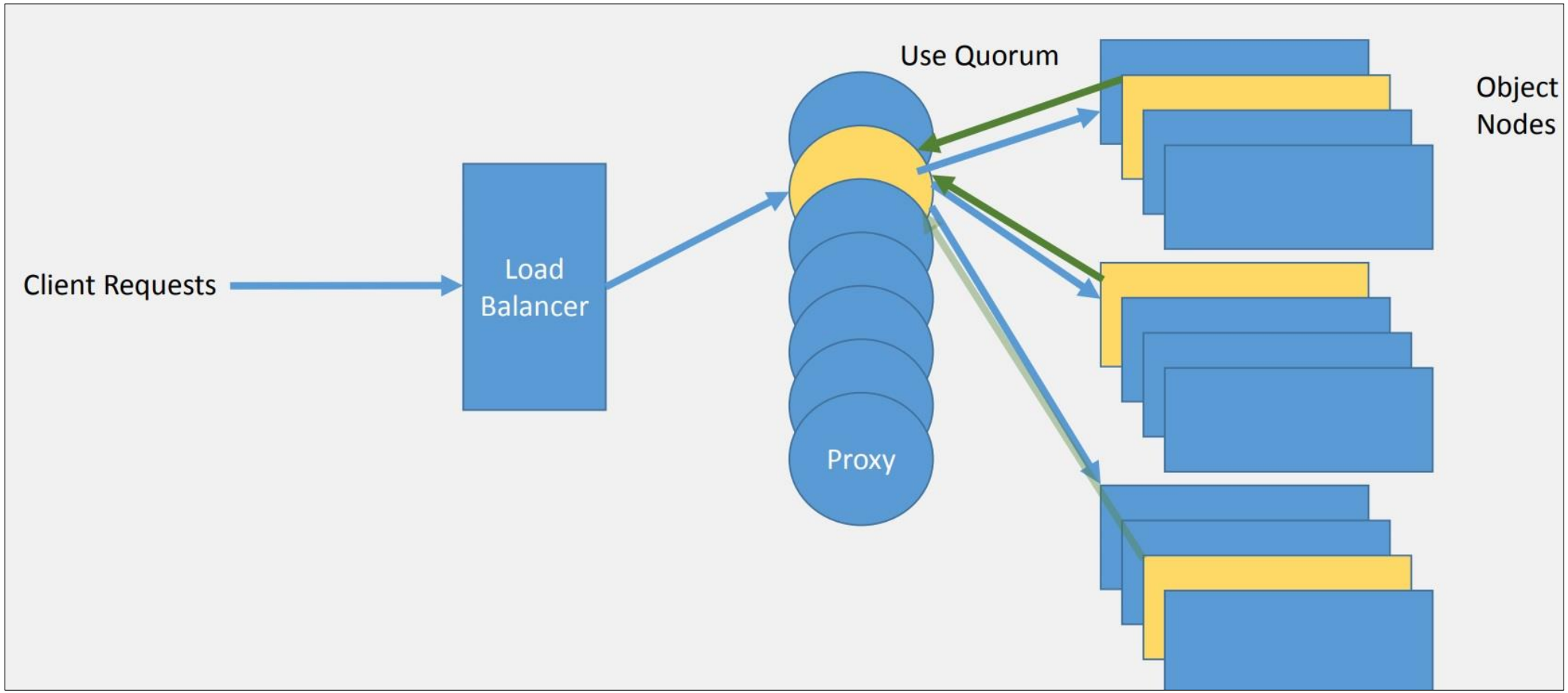
SWIFT API

- https://tuke.sk/blob_storage/auth_account/container/object
- PUT /blob_storage/g_magyar/myblobs/lecture5
- GET /blob_storage/g_magyar/myblobs/lecture5

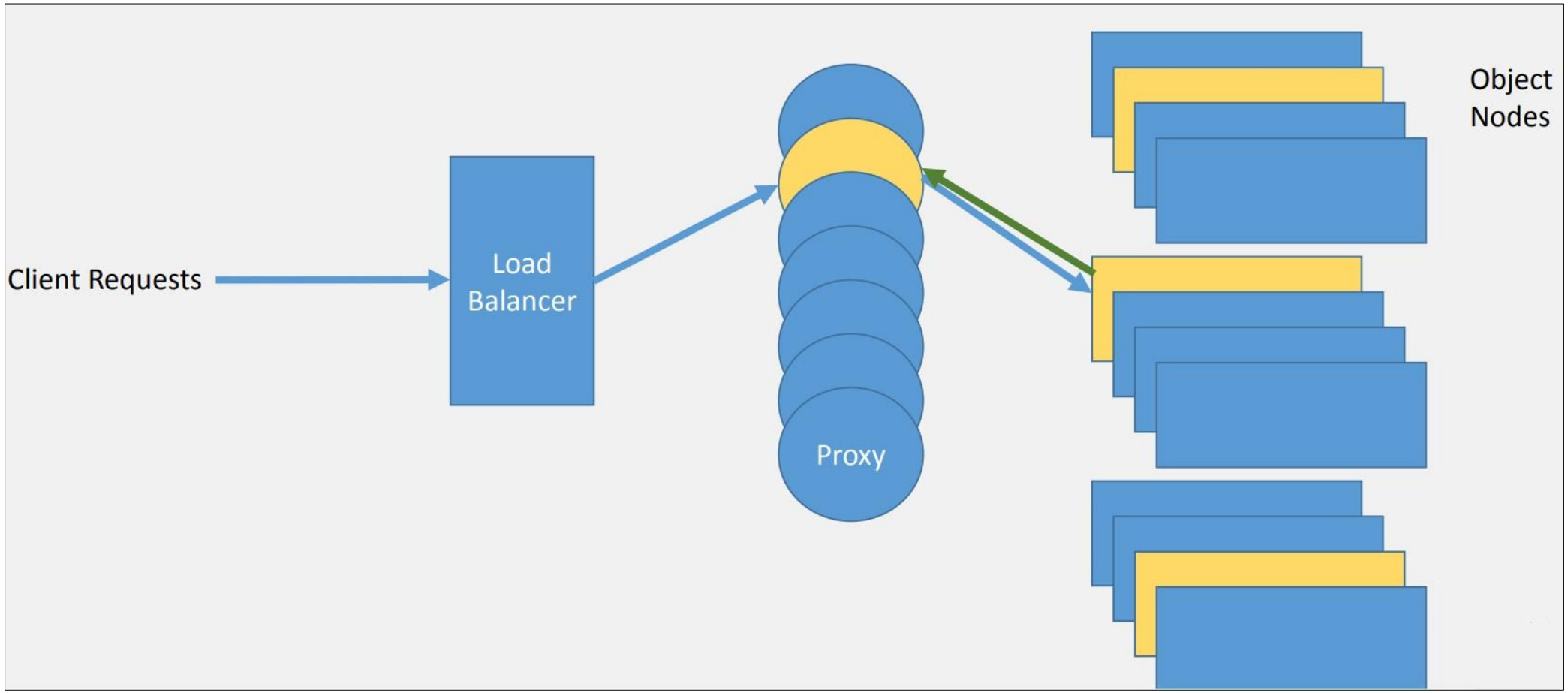
SWIFT COMPONENTS



SWIFT WRITE REQUESTS



SWIFT READ REQUESTS



SWIFT - DETAILS

- checksums with each object
- auditing and active replication
- any sized disks

AMAZON S3 - DEFINITION

Online file storage web service offered by Amazon Web Services. Amazon S3 provides storage through web service interfaces REST, SOAP, BitTorrent.

AMAZON S3 – USE CASES

- scalability, high availability, low latency – 99.99% availability
- files up to 5 terabytes
- objects stored in buckets owned by users
- user assigned keys refer to objects

- Amazon Machine Images (exported as a bundle of objects)
- Netflix, reddit, Dropbox, etc.

AMAZON S3

- a **bucket** is a container for objects and describes location, logging, accounting, and access control
  - a bucket has a name that must be **globally unique**.
  - http://*bucket*.s3.amazonaws.com
  - http://*bucket*.s3-*aws-region*.amazonaws.com

- a bucket can hold any number of objects, which are files of up to 5 TB.
  - http://bucket.s3.amazonaws.com/object
  - http://johnsmith.s3.amazonaws.com/photos/puppy.jpg

AMAZON S3 – FUNDAMENTAL OPERATIONS

- http://*bucket*.s3.amazonaws.com/*object*

- POST a new object or update an existing object
- GET an existing object from a bucket
- DELETE an object from the bucket
- LIST keys present in a bucket, with a filter

AMAZON S3 – WEAK CONSISTENCY MODEL

- updates to a single key are atomic
- Amazon S3 achieves high availability by replicating data across multiple servers within Amzon's data centers. If a PUT request is successful, your data is safely stored. However:
  - a process writes a new object to Amazon S3 and immediately attempts to read it. Until the change is fully propagates, Amazon S3 might report "key does not exist."
  - a process writes a new object to Amazon S3 and immediately lists keys within its bucked. Until the change is fully propagated, the object might not appear in the list.
  - a process replaces an existing object and immediately attempts to read it. Until the change is fully propagated, Amazon S3 might return the prior data.
  - a process deletes an existing object and immediately attempts to read it. Until the deletion is fully propagated, Amazon S3 might return the deleted data.

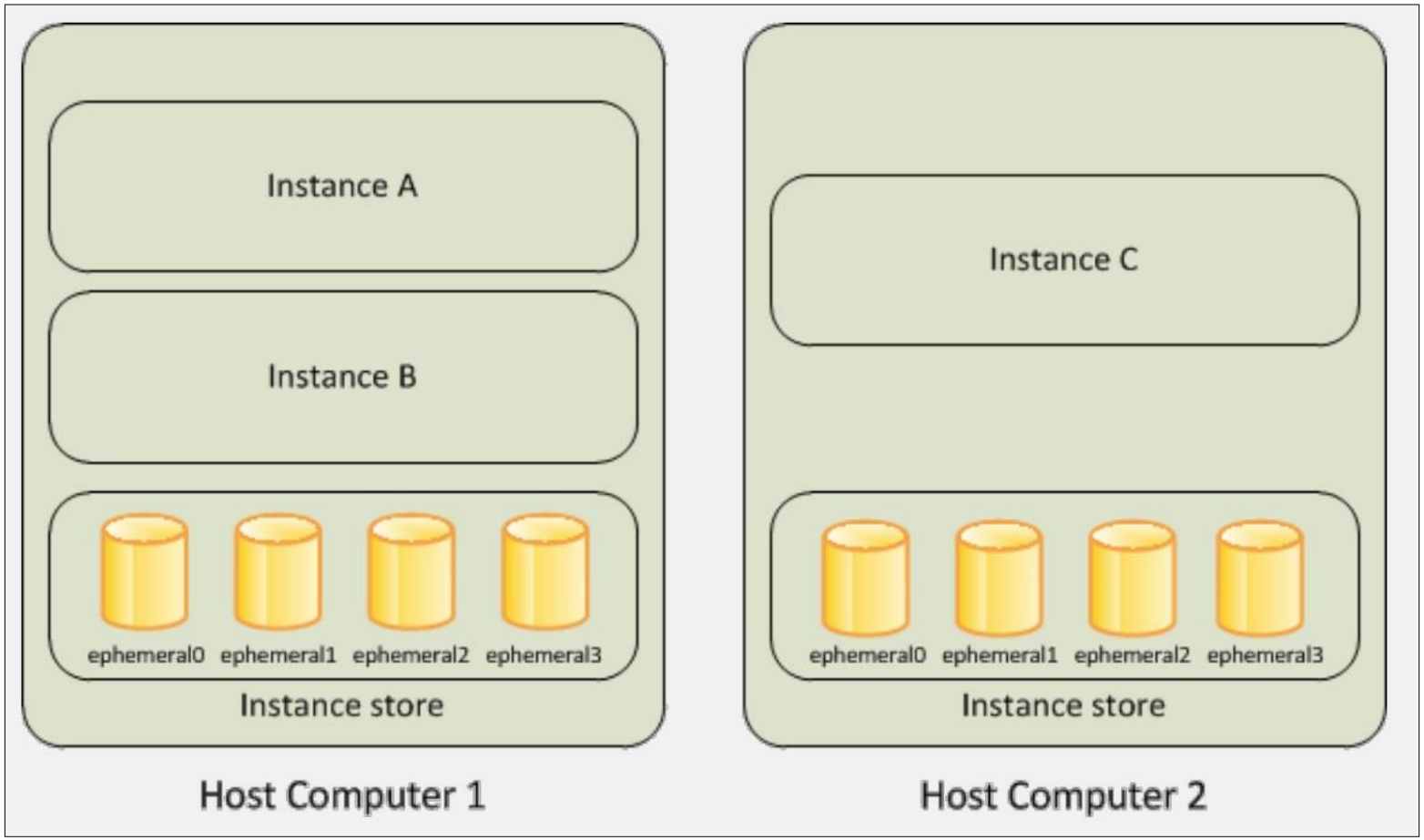
AMAZON S3 – COMMAND LINE INTERFACE

```
aws  s3  mb  s3://bucket
aws  s3  cp  localfile s3://bucket/key
aws  s3  mv  s3://bucket/key  s3://bucket/newname
aws  s3  ls  s3://bucket
aws  s3  rm  s3://bucket/key
aws  s3  rb  s3://bucket
aws  s3  help
aws  s3  ls help
```

AMAZON AWS INSTANCE STORE

- instance stores are another form of cloud-hosted **temporary** block-level storage
  - these are provided as part of an instance, such as an Amazon EC2
- their contents will be lost if the cloud instance is stopped
  - but offer higher performance and bandwidth to the instance
  - located on disks that are physically attached to the host computer
- they are best used for temporary storage such as caching or temporary files, with persistent storage held on a different type of server

AMAZON AWS INSTANCE STORE (2)



INSTANCE STORE LIFETIME

- data persists only during the lifetime of its associated instance
  - it persists a reboot
- data lost if
  - the underlying disk drive fails
  - the instance stops
  - the instance terminates
- you can get reliability by
  - a distributed file system
  - backup to S3 or EBS

INSTANCE STORE SIZE

- a typical instance store is small
  - SSD: can be anywhere from around 80 GB to 320 GB SSD, up to 3840 GB
  - HDD: when available up to 1680 GB

AMAZON AWS EBS

- EBS volumes are highly available and reliable
- can be attached to running instances in the same availability zones
- use when data must be quickly accessible and requires long-term persistence
- support encryption
- up to 16 TB in size

AMAZON AWS EBS (2)

- general purpose SSD
- provisioned SSD
  - provision a specific level of performance
- throughput optimized HDD
  - low cost magnetic storage
  - large, sequential workloads, such as log processing
- cold HDD
  - inexpensive magnetic storage

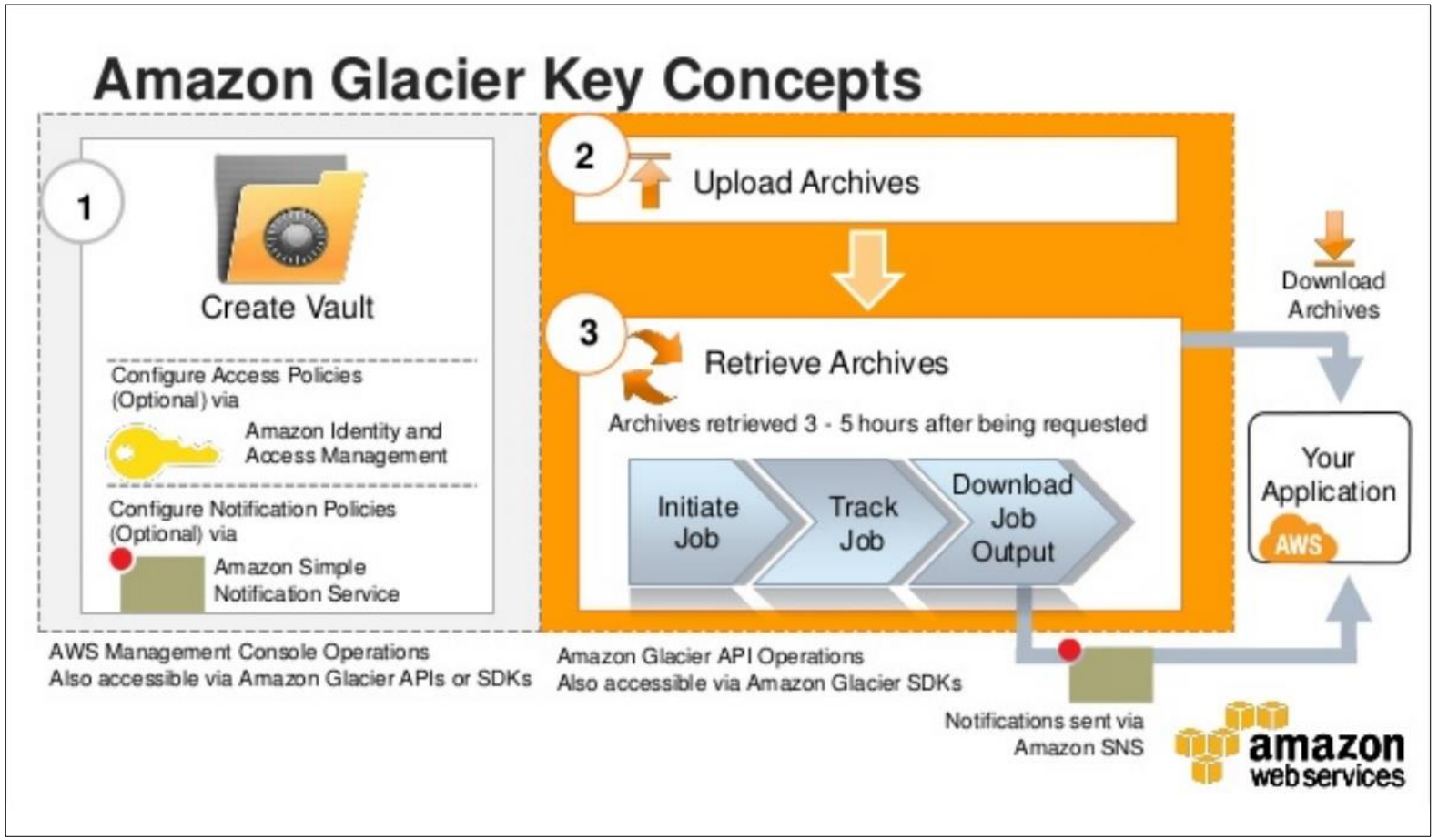
AMAZON AWS GLACIER

- allows you to archive your data
- very low cost, $0,007 per GB per month
- very durable
  - average annual durability of 99.999999999%
- each single archive up to 40 TB

AMAZON AWS GLACIER (2)

- archives stored in vaults
- the main access point to glacier is S3
- typically takes between ***3 to 5 hours*** to prepare a download request
  - after that you have 24 hours to download from the staging location

AMAZON AWS GLACIER (3)



AMAZON AWS EFS

- Elastic File System
- motivation: enterprise customers need a large distributed file system
  - S3 is large and distributed, but it is an object store without performance guarantees and eventual consistency model
  - block storage (EBS, instance store) are small
    - enterprise can build a distributed file system on top of these, but it requires operational expertise
  - glacier: good for only archival storage
- EFS provides a fully NFSv4 compliant network file system

AMAZON AWS EFS (2)

- SSD backed
- highly available and highly durable
  - files, directories, and links are stored redundantly across multiple Availability Zones within an AWS region
- grow or shrink as needed
  - no need to pre-provision capacity

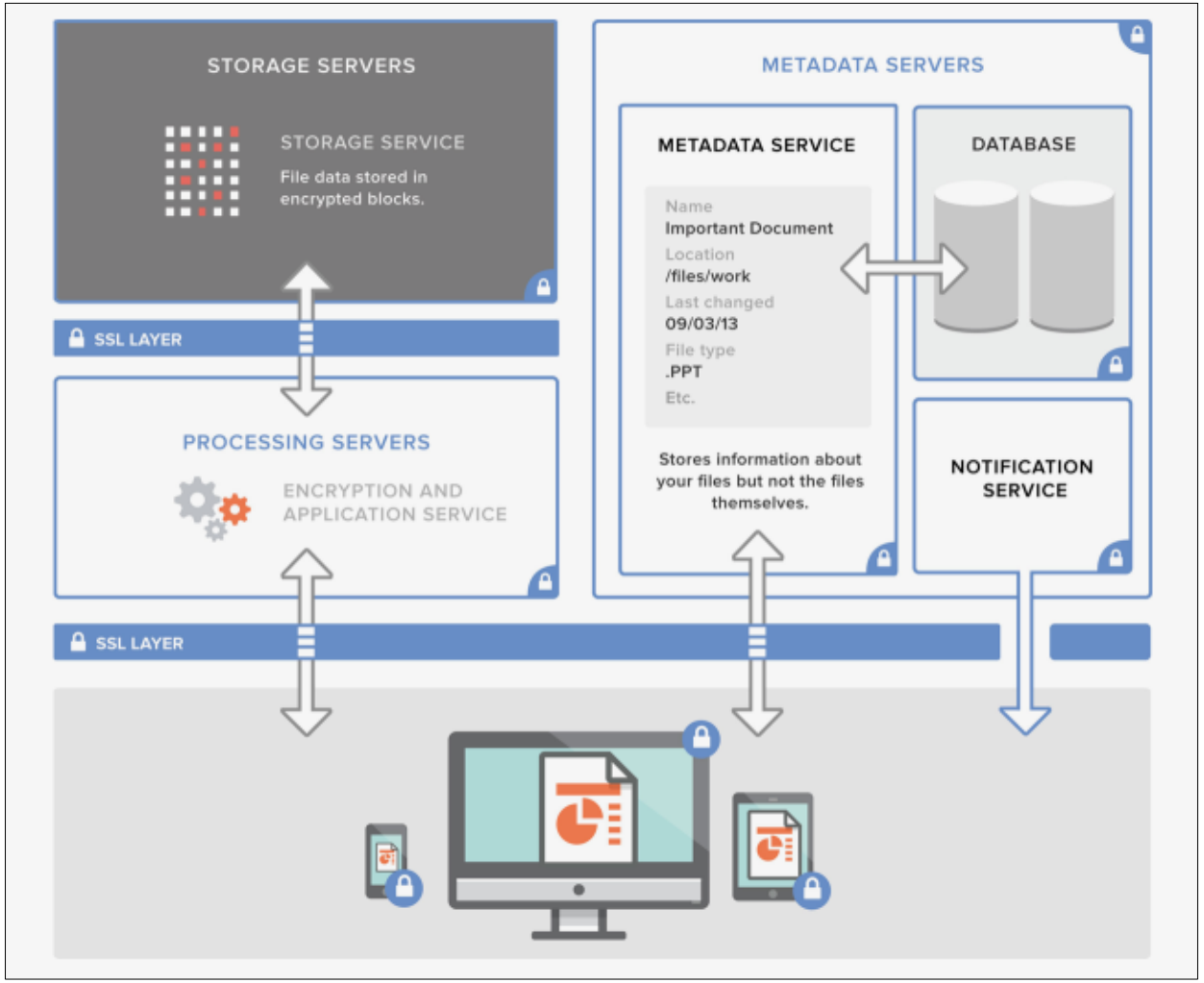
AMAZON AWS EFS VS EBS

		Amazon EFS	Amazon EBS PIOPS
Performance	Per-operation latency	Low, consistent	Lowest, consistent
	Throughput scale	Multiple GBs per second	Single GB per second
Characteristics	Data Availability/Durability	Stored redundantly across multiple AZs	Stored redundantly in a single AZ
	Access	1 to 1000s of EC2 instances, from multiple AZs, concurrently	Single EC2 instance in a single AZ
	Use Cases	Big Data and analytics, media processing workflows, content management, web serving, home directories	Boot volumes, transactional and NoSQL databases, data warehousing & ETL

DROPBOX

- interesting case study
- Dropbox offers cloud file storage
  - easily synced across multiple devices
  - accessible through web interface, mobile apps, and directly integrated with the file system on PCs
- Dropbox itself uses clouds!
  - metadata stored in Dropbox servers
  - actual files stored in Amazon S3
  - Amazon EC2 instances run the logic

DROPBOX ARCHITECTURE

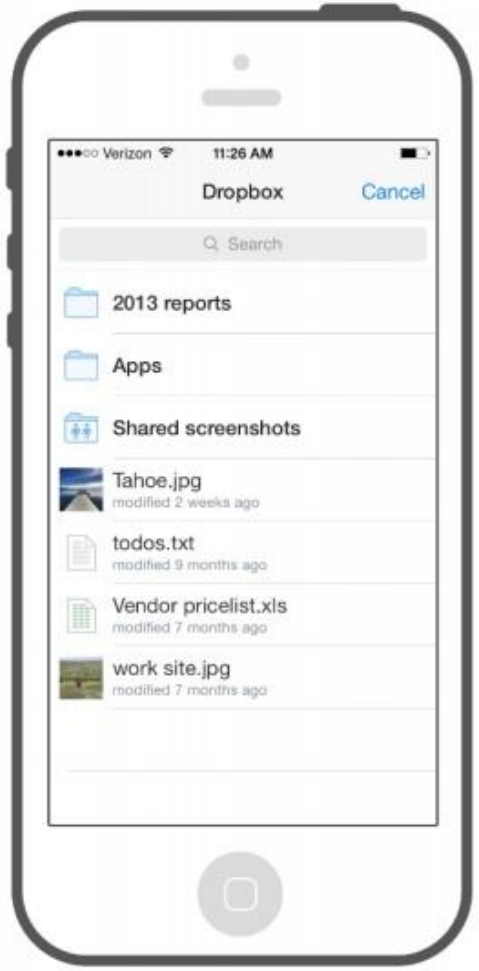


DROPBOX API

- two levels of API access to Dropbox
  - drop-ins
    - cross-platform UI components that can be integrated in minutes
    - ***chooser*** allows instant access to files in Dropbox
    - ***saver*** makes saving files to Dropbox easy
  - core API
    - support for advanced functionality like search, revisions, and restoring file
    - better fit for deeper integration

DROP-IN API

- simple objects
  - ***chooser*** available for JavaScript, Android and iOS
  - ***saver*** on web and mobile web
- handles all the authentication (OAuth), file browsing
- chooser object returns the following:
  - link: URL to access the file
  - file name
  - file size
  - icon
  - thumbnails
- saver
  - pass in URL, filename and options



CORE API

- many languages and environments
  - Python, Ruby, PHP, Java, Android, iOS, OS X, HTTP
- based on HTTP and OAuth
  - OAuth v1, OAuth v2
- Low-level calls to access and manipulate a user's Dropbox account
  - create URL schemes
  - upload files
  - download files
  - list files and folders
  - delta
  - metadata access
  - create and manage file sharing