SafeCloud

Using Several Clouds to Improve Storage Dependability: From DepSky to SCFS and Beyond

Miguel P. Correia

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Joint work with Alysson Bessani, B. Quaresma, F. André, P. Sousa, R. Mendes, T. Oliveira, N. Neves, M. Pasin, P. Verissimo, M. Pardal, E. Silva, F. Apolinário, D. Matos

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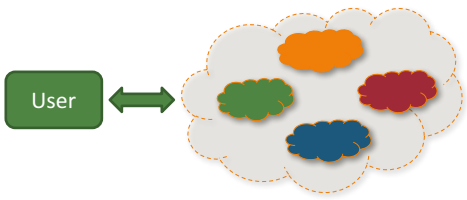
Cloud-of-Clouds

- Consumer runs service on a set of clouds forming a virtual cloud, what we call a cloud-of-clouds
- Related to the notion of federation of clouds
  - Federation of clouds – a virtual cloud created by cloud providers; requires cooperation between providers
  - Cloud-of-clouds – an ad-hoc virtual cloud created by consumers; no cooperation between clouds needed



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Cloud-of-Clouds dependability+security

- There is redundancy and diversity between clouds
- so even if some clouds fail a cloud-of-clouds that implements replication can still guarantee:
  - Availability – if some stop, the others are still there
  - Integrity – if some corrupt data, data is still at the others
  - Disaster-tolerance – clouds can be geographically far
  - No vendor lock-in – several clouds anyway
- plus, although, not specific to cloud-of-clouds:
  - Confidentiality (from clouds) – encryption
  - Confidentiality/integrity (from users) – access control

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Outline

- DepSky – file storage in clouds-of-clouds
- SCFS – file system in clouds-of-clouds
- SafeCloud-FS – file system in clouds-of-clouds

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DEPSKY: FILE STORAGE IN CLOUDS-OF-CLOUDS

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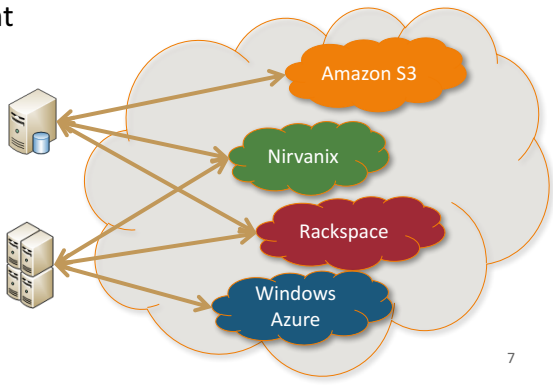
DepSky

- Client-side library for cloud-of-clouds storage
  - File storage, similar to Amazon S3: read/write files, etc.
- Use storage cloud services (S3, etc.) as they are:
  - All code at the client
- Data is updatable
  - Byzantine quorum replication protocols for consistency



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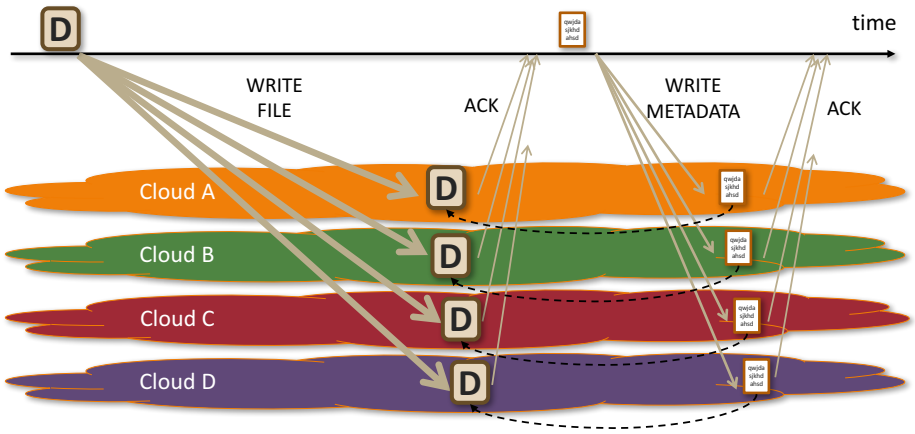
Write protocol



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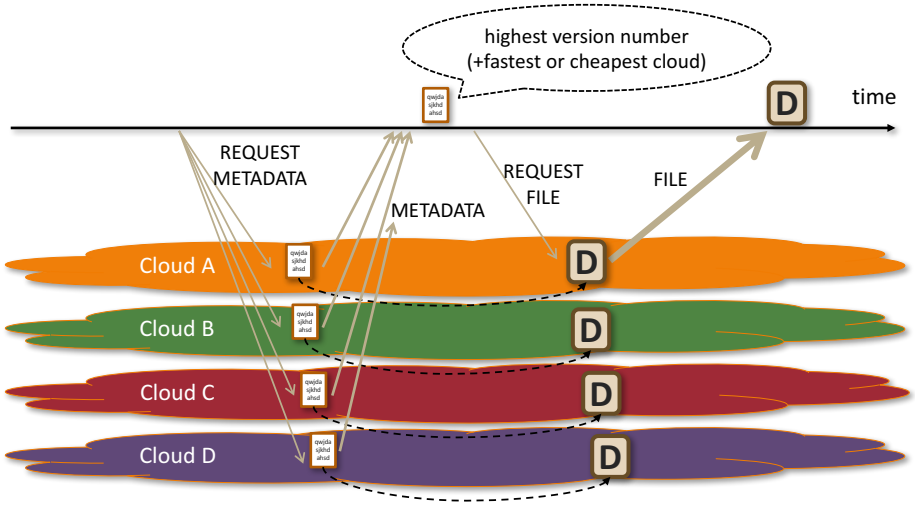
Read protocol



File is fetched from other clouds if signature doesn't match the file

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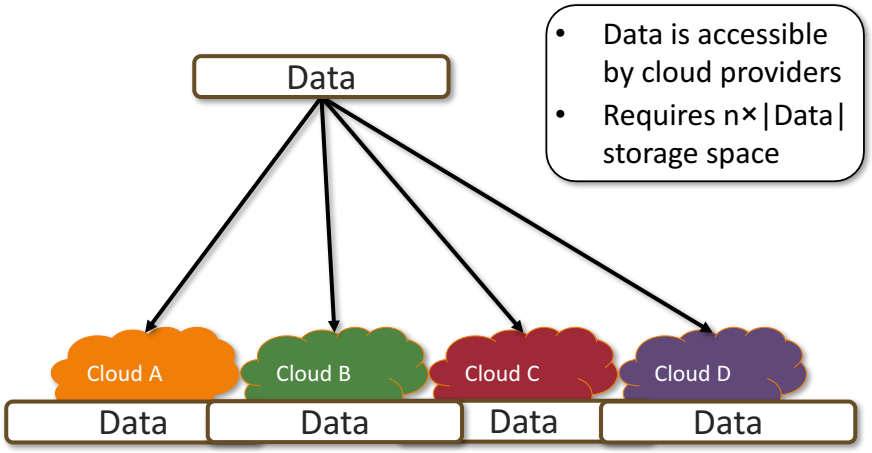
DepSky-A: limitations



- Data is accessible by cloud providers
- Requires n×|Data| storage space

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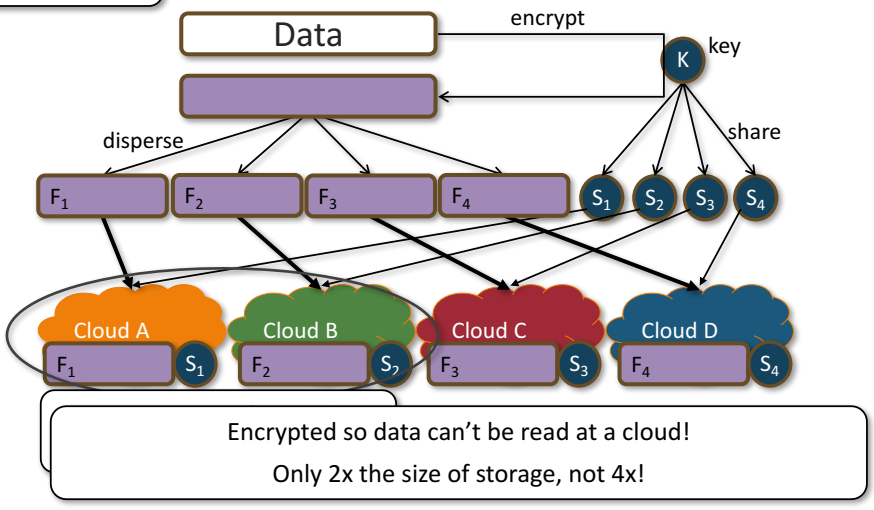
DepSky-CA: combining erasure codes and secret sharing

Only for data, not metadata



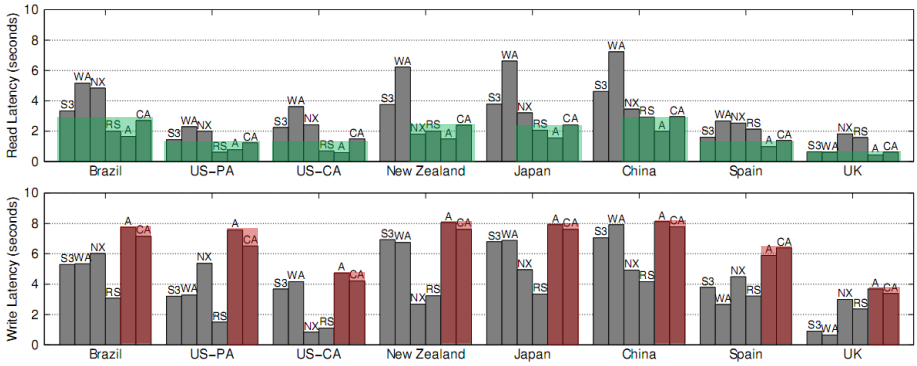
Encrypted so data can't be read at a cloud!

Only 2x the size of storage, not 4x!

DepSky latency

100KB files, clients in PlanetLab nodes

DepSky's **read** latency is close to the cloud with the **best** latency



DepSky's **write** latency is close to the cloud with the **worst** latency

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SCFS: FILE SYSTEM IN CLOUDS-OF-CLOUDS

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Storage vs. File System (DepSky vs. SCFS)

- Storage (DepSky)
  - API: simple operations over data blocks
  - same consistency as clouds
  - `create(id)`
  - `read(fd)`
  - `write(fd,block)`
  - `delete(fd)`
  - `lock(fd)`
  - `unlock(fd)`
  - `setACL(fd)`
- File system (SCFS)
  - API: ~POSIX, so unmodified apps can use it (uses FUSE)
  - strong consistency
  - `open(path,flags)`
  - `read(fd,buffer,length,offset)`
  - `write(fd,buffer,length,offset)`
  - `chmod(path,mode)`
  - `mkdir(path,mode)`
  - `flush, fsync, link, rmdir, symlink, chown,...`

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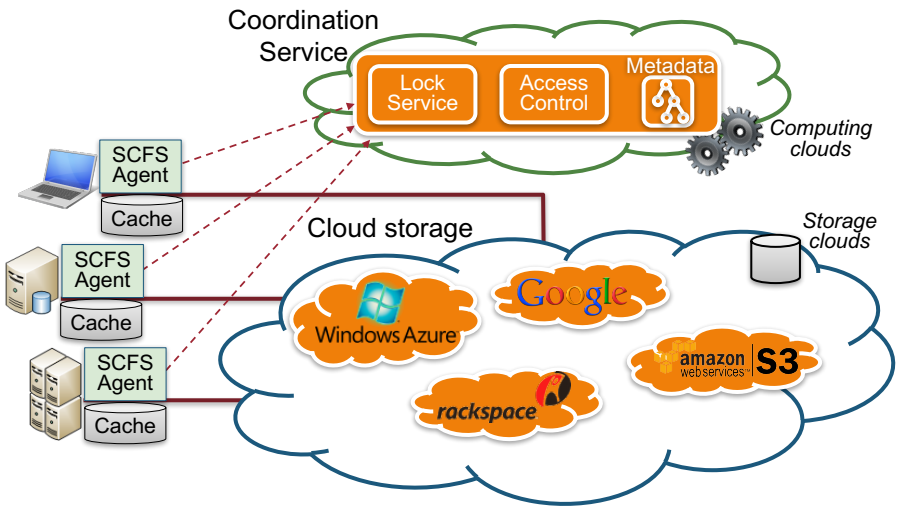
SCFS architecture



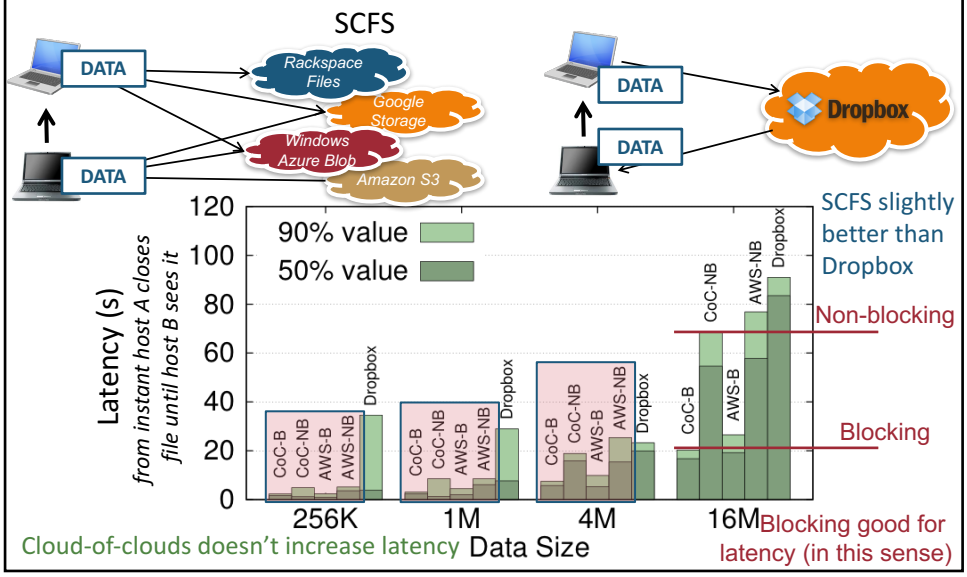
Features

- Data layout/access pattern
  - Each file is an object (single-block file)
  - Multiple versions of the files are maintained
  - Always write, avoid reading (exploiting free writes)
- Caching
  - File cache: persistent (to avoid reading)
    - Local storage is used to hold copies of all/most client files
    - Opened files are also maintained in main-memory
  - Metadata cache: short-lived, main-memory
    - To deal with bursts of *metadata* requests

Features

- Consistency
  - Consistency-on-close semantics
    - when user closes a file, all updates he did become observable by the rest of the users
  - Locks to avoid write-write conflicts
- Modular coordination
  - Metadata is stored in a coordination service
    - e.g., Apache Zookeeper (crash fault-tolerant), our own DepSpace (Byzantine/intrusion-tolerant)
  - Also used for managing file locks
  - Separate data from metadata

Sharing latency: SCFS vs DropBox



SAFECLOUD-FS – AN ENHANCED CLOUD-OF-CLOUDS FILE SYSTEM

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SCFS: opportunities

- Coordination service stores metadata (e.g., filenames, directories) in clear
- Integrity verification of data stored in a cloud requires first downloading the data
- Intrusion recovery – when a user account is compromised and data corrupted, recovery has to be done manually

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SafeCloud-FS

- Based on SCFS, with the features just explained, but:
- Coordination service HomomorphicSpace
  - Based on DepSpace but supports homomorphic operations
  - Based on the MorphicLib library (Java)
    - Operations: searchable, order preserving, summable, multipliable
  - Stores file metadata encrypted
- Integrity verification: SafeAudit
  - integrity verification of stored data without downloading it, using homomorphic signatures
- Intrusion recovery automatically with SafeRCloud

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WRAP-UP

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Conclusions

- Masking faults / intrusions using clouds-of-clouds
- DepSky: storage clouds-of-clouds
  - Availability, integrity, disaster-tolerance, no vendor lock-in, confidentiality
- SCFS: a cloud-backed file system
  - Based on DepSky and providing similar guarantees but near-POSIX API
- SafeCloud-FS: an enhanced cloud-backed file system
  - Ongoing work

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SafeCloud

Thank you

- Papers:
  - DepSky: Dependable and Secure Storage in a Cloud-of-Clouds. ACM Transactions on Storage, 2013 (also EuroSys 2010)
  - SCFS: a Shared Cloud-backed File System. Usenix Annual Technical Conference (ATC), 2014
- Code:
  - DepSky: http://cloud-of-clouds.github.io/depsky/
  - SCFS: http://cloud-of-clouds.github.io/SCFS/
- My web: http://www.gsd.inesc-id.pt/~mpc/

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