AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Managing data availability and integrity in federated cloud storage

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Agenda

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Motivation

Cloud storage problems

- data stored on external resources of (untrusted) cloud provider
- best-effort SLAs definition, return of costs otherwise
- cloud vendor lock-in effect
- numerous cloud storage failures and security flaws [1]
  - deleted emails, millions of blocked accounts in Gmail service
  - multiple Amazon S3 downtimes reports
  - unauthorized access to files in GoogleDocs

Cloud storage data integrity challenges

- network latency and bandwidth limits
  - fine-grained access pattern overhead
  - WAN networks (Internet) bandwidth outages
- costs of [2]
  - data storage (per volume)
  - data transfer (per # of requests, per volume)
- simplified API, no computation available without retrieval

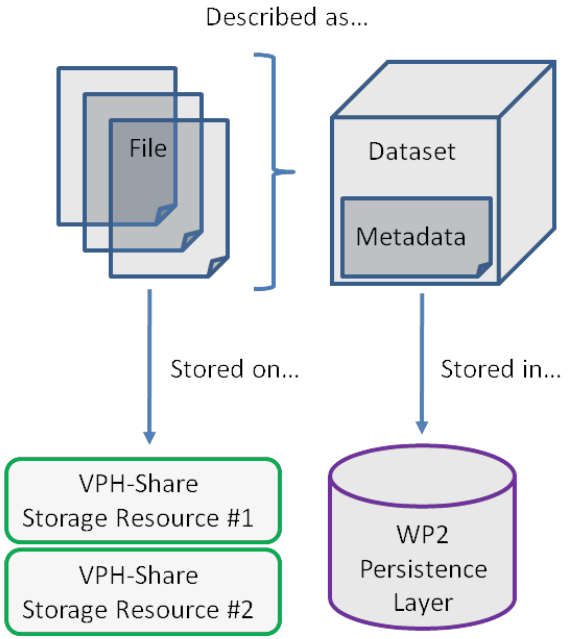
[1] C. Cerin et al: Downtime statistics of current cloud solutions, IWGCR, June 2013

[2] Amazon S3, Google Cloud Storage, Rackspace storage official pages

VPH-Share project background [1]

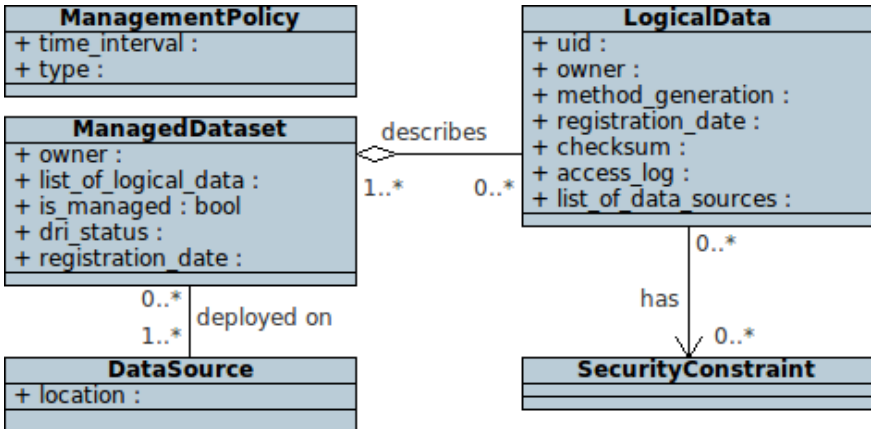
Data in VPH-Share

- mostly **static** and **sensitive**, biomedical data
- stored in federation of cloud storage providers to
  - avoid vendor lock-in effect
  - provide fault tolerance against provider failures
- storage entity defined as **dataset** (simply, a set of files)



Data integrity requirements

- Periodical monitoring of data availability and integrity
- Network-efficient data validation
  - reduce whole-file retrieval overhead
  - reduce costs
- Replication of datasets in cloud federation



[1] P. Nowakowski et al: VPH-Share WP2: Data and Compute Cloud Platform, Deliverable 2.2, VPH-Share 2011

Objectives

The aim of this thesis is to develop a method to efficiently monitor the availability and integrity of data stored in federation of cloud storages.

Detailed objectives of this work

- literature research on efficient cloud storage validation algorithm
- design of network-efficient data validation algorithm
- design and implementation of validation web service prototype
- integration with VPH-Share platform

Overview of methods for data integrity

Data integrity building blocks

- Hash functions (MD5, SHA-1, SHA-256)
- Message authentication code (MAC) – integrity and authenticity assurance
- Error correcting code (ECC) – corruption detection and correction

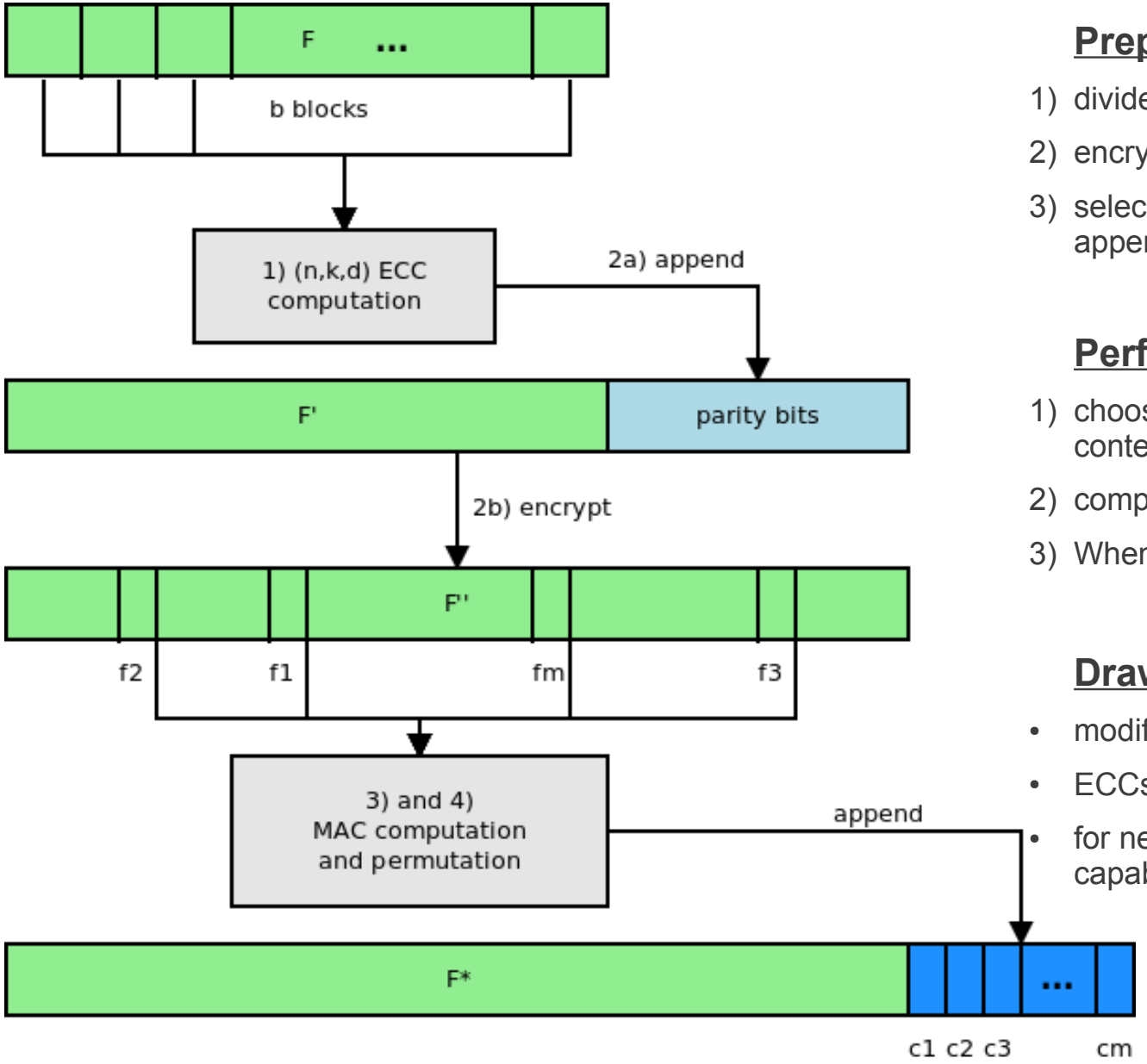
Popular approaches

- MD5/SHA-1 software package checksumming
- integrity checksums of messages in networking
- Widespread use of ECCs in hardware solutions

Existing methods fail in cloud storage model due to

- huge amount of data
- stored on external resources

Proof of Retrievability



Prepare for data validation

1) divide a file F into b blocks and apply ECCs
2) encrypt the file with appended ECCs
3) select m blocks out of M, compute their MACs and append to the file

Perform data validation

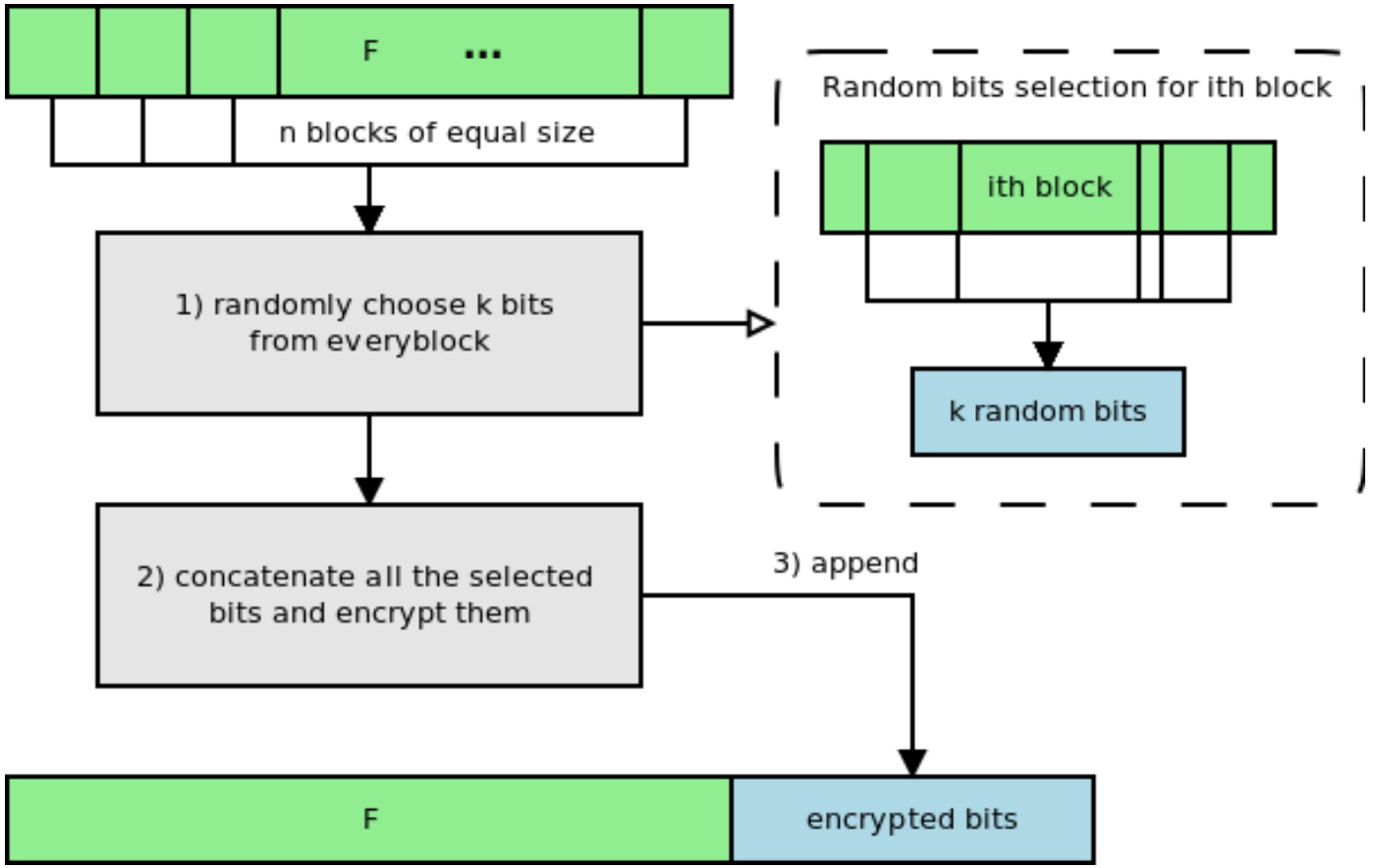
1) choose k out of m blocks and download their content
2) compute MACs and compare with the originals
3) When retrieving whole file, apply ECCs

Drawbacks of the approach

- modification of file F
- ECCs storage overhead
- for network-efficient validation, requires computing capabilities on the prover side

A. Juels and B. Kaliski: PORs: Proofs of Retrievability for Large Files, ACM CCS, 2007

Data integrity proof



Drawbacks of the approach

- Inefficient with regard to current cloud REST APIs, where every non-contiguous bit range requires separate HTTP request

Prepare for data validation

1) divide a file F into n blocks and select randomly k bits from every block using key generator
2) concatenate all selected bits and encrypt them
3) append encrypted bits to the end of file

Perform data validation

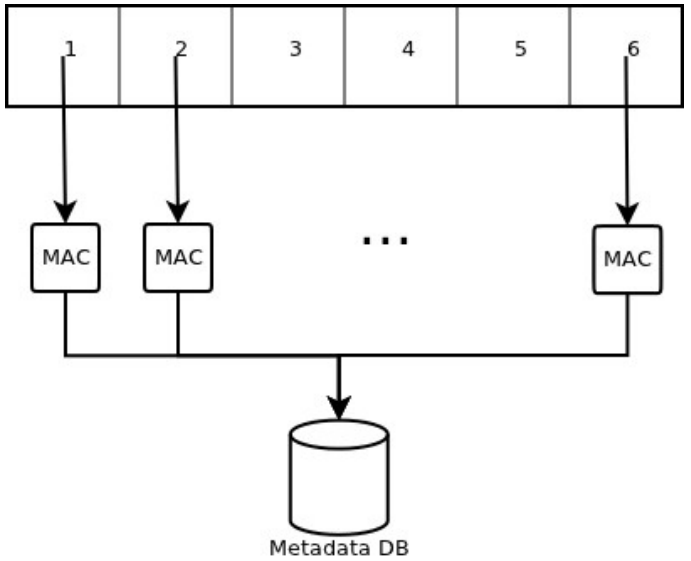
1) select the same bits and concatenate
2) compare with the originals

S. Kumar and A. Saxena: Data integrity proofs in cloud storage, COMNETS, 2011

Data validation algorithm

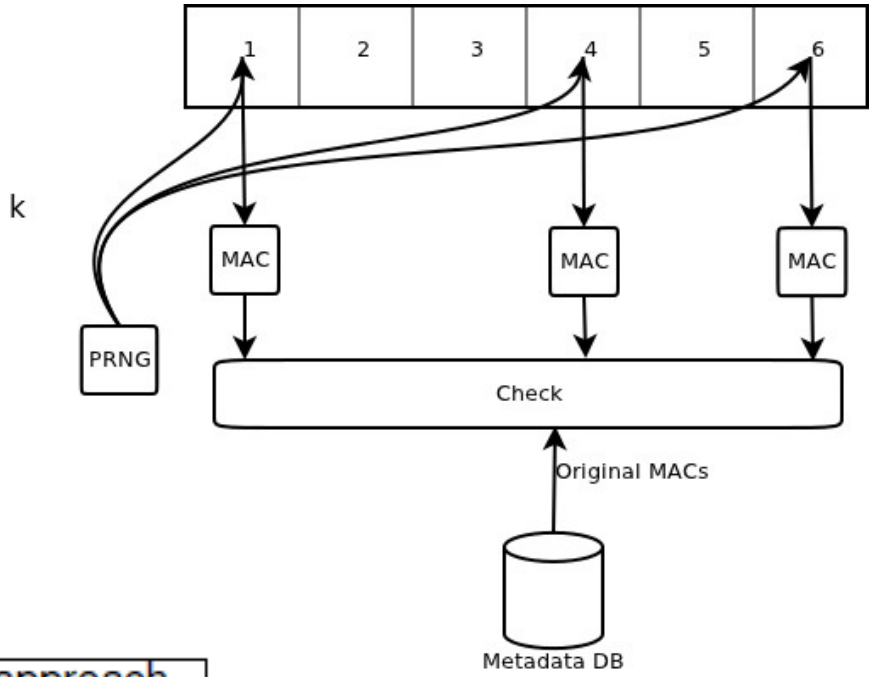
Prepare for data validation

1) divide file F into n equal chunks
2) compute MAC checksum for every chunk and store



Perform data validation

1) randomly select k out of n chunks
2) compute MAC checksum of selected chunks and compare with the originals



Metric	our approach	whole-file approach
E_{det}	$\frac{k}{n}$	1
N_{over}	$\sim F \times \frac{k}{n}$	$\sim F$
T_{exec}	$\sim k \times (\frac{F}{n \times speed} + latency)$	$\sim \frac{F}{speed} + latency$

$E_{det} - error\ detection\ rate$

$N_{over.} - network\ overhead$

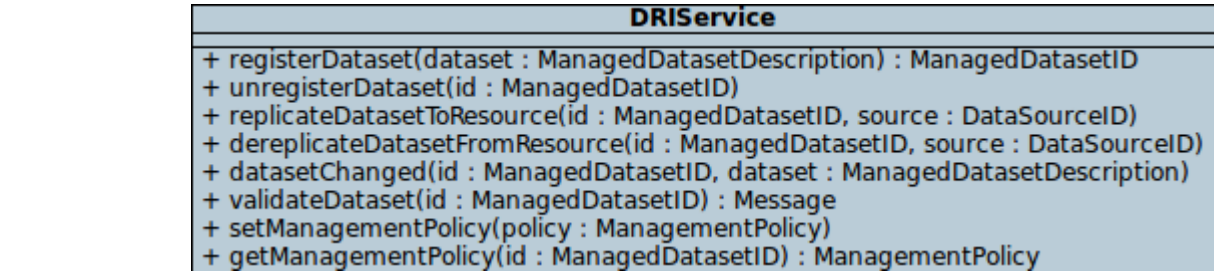
$T_{exec} - time\ complexity$

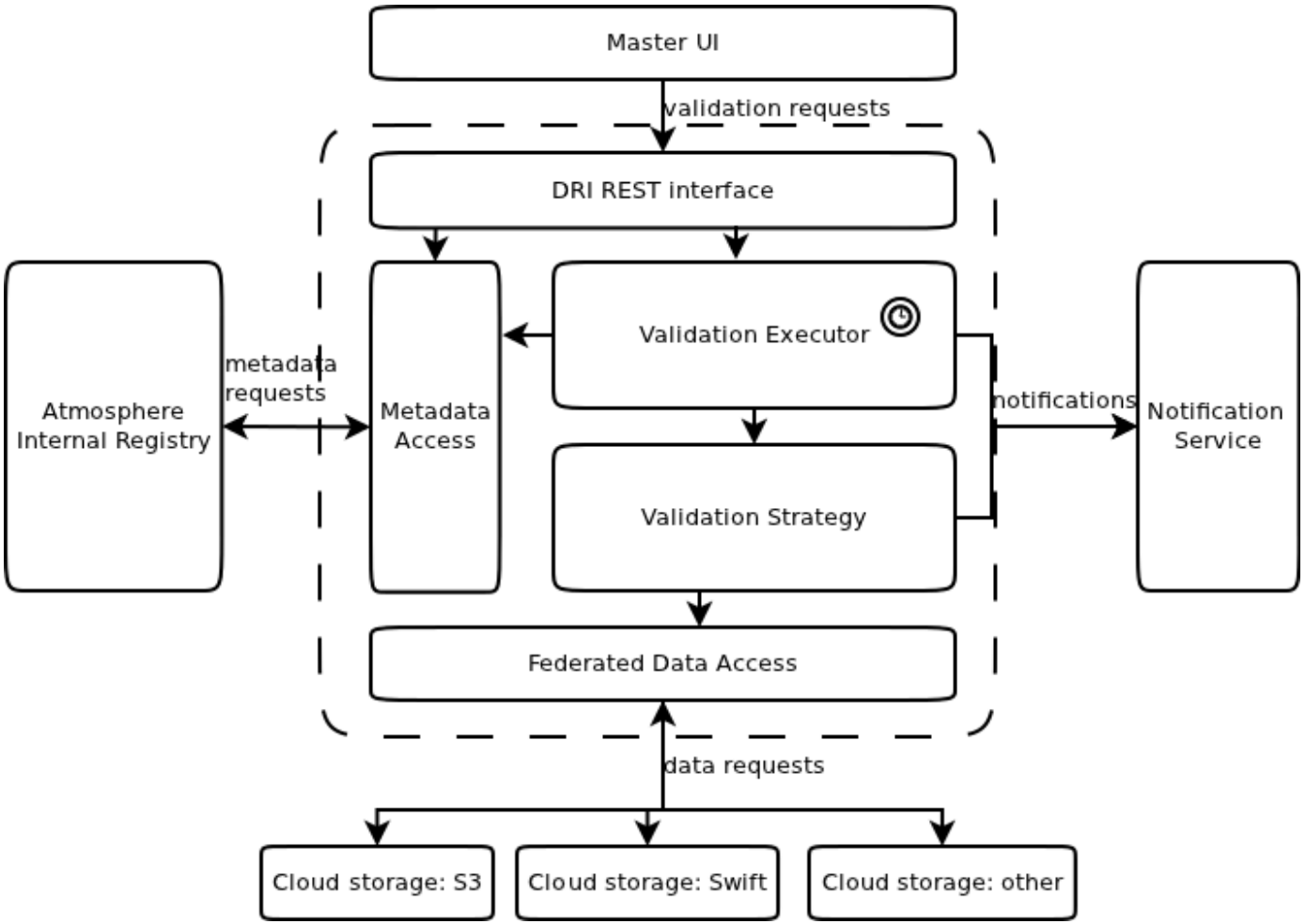
$F - file\ sizze$

Design of Data Reliability and Integrity (DRI)

DRI service

1) stateless REST web service in VPH-Share cloud environment
2) periodical and on-request probabilistic data validation of data in federation of cloud storages
3) datasets and validation metadata stored in AIR registry
4) notifying scientific users via Notification service
5) asynchronous calls and batch execution





Implementation technologies

- JClouds library – generic cloud storage abstraction
- Quartz – task scheduling
- JAX-RS – REST web service
- Java, Guice, Guava, Tomcat

DRI Notification Service

Dataset name	Notification status	Execution time	Time scheduled
test_dataset	Integrity errors detected	2s	8/10/13 12:52 PM

The dataset test_dataset is INVALID

Below is the detailed validation report:

Logical data identifier	Integrity status
moon.jpg	INVALID
earth.jpg	INVALID
time-machine.txt	UNAVAILABLE

test_dataset	Integrity errors detected	2s	8/10/13 12:51 PM

The dataset test_dataset is INVALID

Below is the detailed validation report:

Logical data identifier	Integrity status
moon.jpg	INVALID
time-machine.txt	UNAVAILABLE

test_dataset	Validation success	2s	8/10/13 12:47 PM
test_dataset	Tagged dataset as managed	5s	8/10/13 12:45 PM

Summary and future work

Results

- proposed a network-efficient algorithm for data validation in the cloud
- proposed methodology how to address the problem of providing data reliability and integrity in the cloud
- enabled VPH-Share project users to monitor data integrity and notify in case offailures

Future work

- investigate how to combine DRI monitoring service with federated cloud storage data access layer
- extract DRI functionality and provide it as a reusable component outside of the VPH-Share project
- investigate further improvements of data validation algorithm

Acknowledgement

More at http://dice.cyfronet.pl/VPH-Share

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