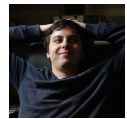
Deuxfleurs Association

`https://garagehq.deuxfleurs.fr/`
Matrix channel: `#garage:deuxfleurs.fr`

Who we are

Alex Auvolat
PhD at Inria, team WIDE; co-founder of Deuxfleurs

Quentin Dufour
PhD at Inria, team WIDE; co-founder of Deuxfleurs



Deuxfleurs
A non-profit self-hosting collective,
member of the CHATONS network

Our objective at Deuxfleurs

Promote self-hosting and small-scale hosting as an alternative to large cloud providers

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Promote self-hosting and small-scale hosting as an alternative to large cloud providers

Why is it hard?

Resilience

(we want good uptime/availability with low supervision)

How to make a stable system

Enterprise-grade systems typically employ:

- RAID
- Redundant power grid + UPS
- Redundant Internet connections
- Low-latency links
- ...

→ it's costly and only worth it at DC scale

How to make a resilient system

Instead, we use:

- Commodity hardware (e.g. old desktop PCs)

How to make a resilient system

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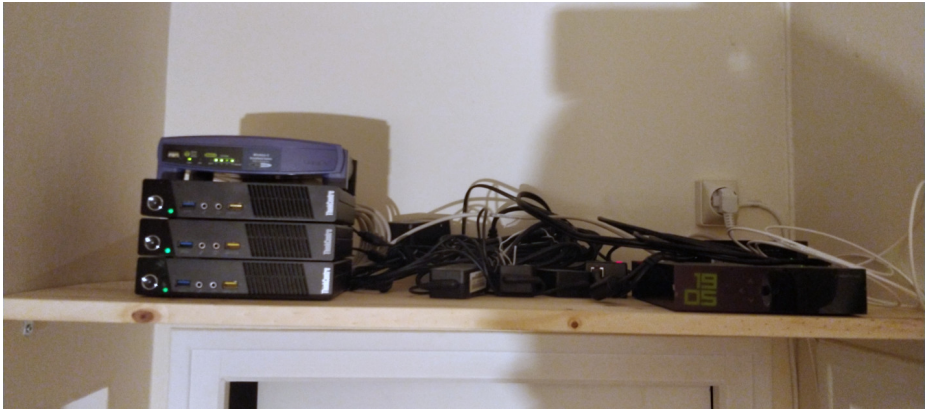

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- Commodity Internet (e.g. FTTB, FTTH) and power grid

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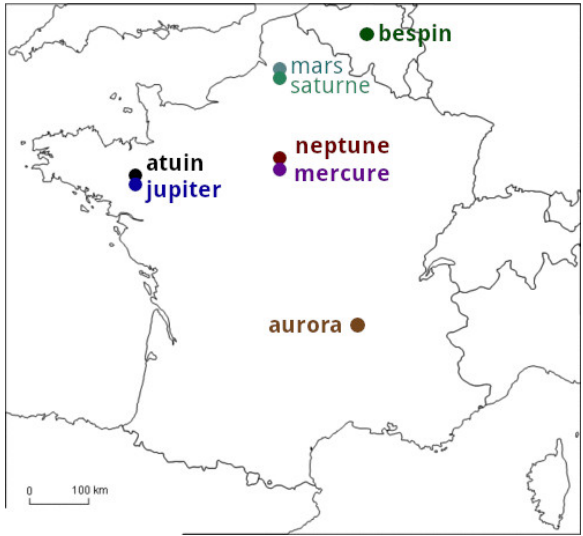
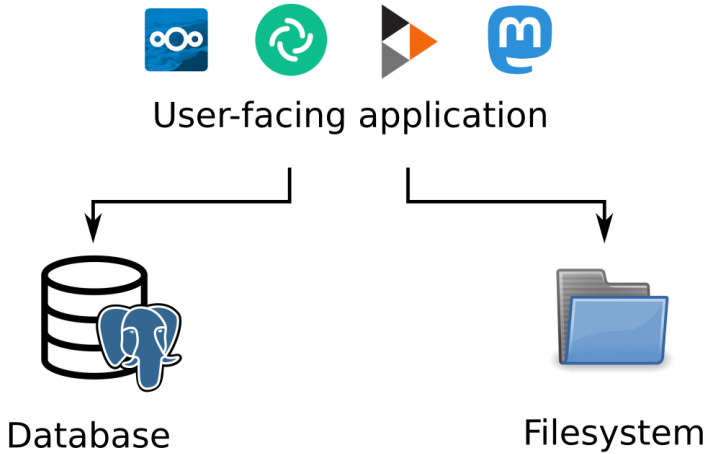
- Commodity hardware (e.g. old desktop PCs)
- Commodity Internet (e.g. FTTB, FTTH) and power grid
- **Geographical redundancy** (multi-site replication)

How to make a resilient system



How to make this happen



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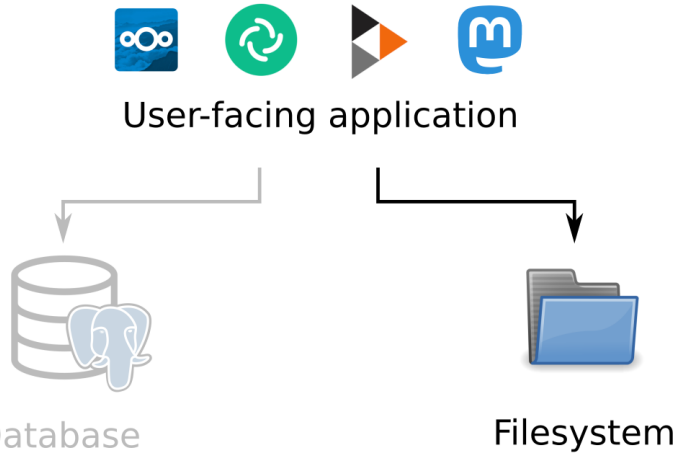

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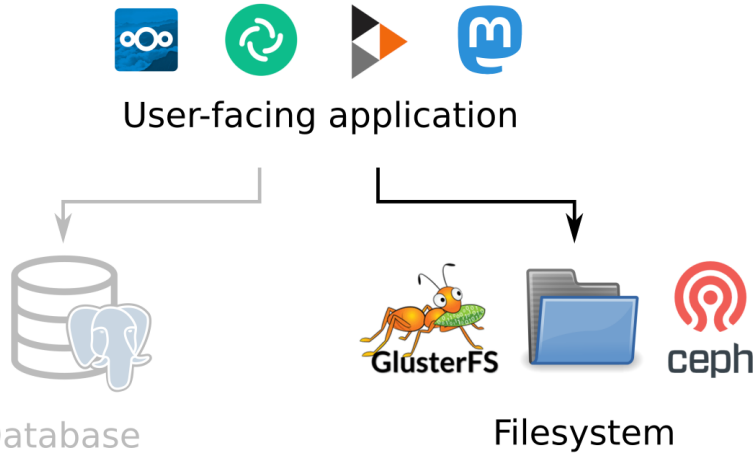


Distributed file systems are slow

File systems are complex, for example:

- Concurrent modification by several processes
- Folder hierarchies
- Other requirements of the POSIX spec

Coordination in a distributed system is costly

Costs explode with commodity hardware / Internet connections
(we experienced this!)

A simpler solution: object storage

Only two operations:

- Put an object at a key
- Retrieve an object from its key

(and a few others)

Sufficient for many applications!

A simpler solution: object storage

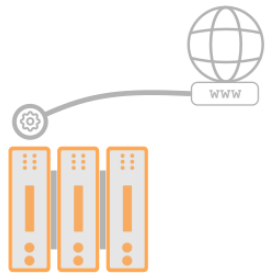
S3: a de-facto standard, many compatible applications

MinIO is self-hostable but not suited for geo-distributed deployments

But what is Garage, exactly?

Garage is a self-hosted drop-in replacement for the Amazon S3 object store

that implements resilience through geographical redundancy on commodity hardware

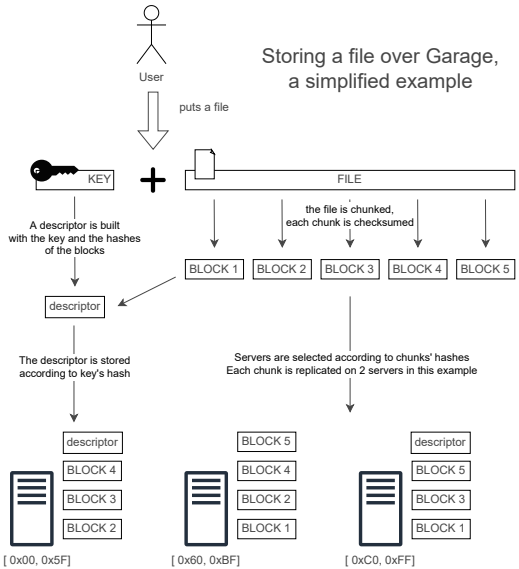


Host a website

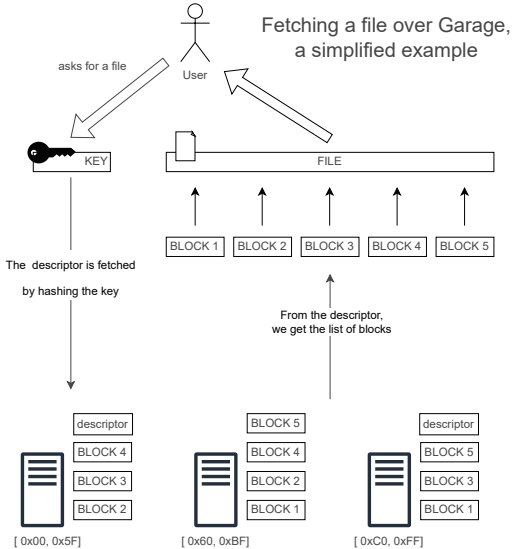
Store Media

Backup Target

Overview


Storing a file over Garage,
a simplified example
User
puts a file
KEY
FILE
the file is chunked,
each chunk is checksumed
A descriptor is built
with the key and the hashes
of the blocks
BLOCK 1
BLOCK 2
BLOCK 3
BLOCK 4
BLOCK 5
descriptor
The descriptor is stored
according to key's hash
Servers are selected according to chunks' hashes
Each chunk is replicated on 2 servers in this example
descriptor
BLOCK 4
BLOCK 3
BLOCK 2
[0x00, 0x5F]
BLOCK 5
BLOCK 4
BLOCK 2
BLOCK 1
[0x60, 0xBF]
descriptor
BLOCK 5
BLOCK 3
BLOCK 1
[0xC0, 0xFF]

Overview

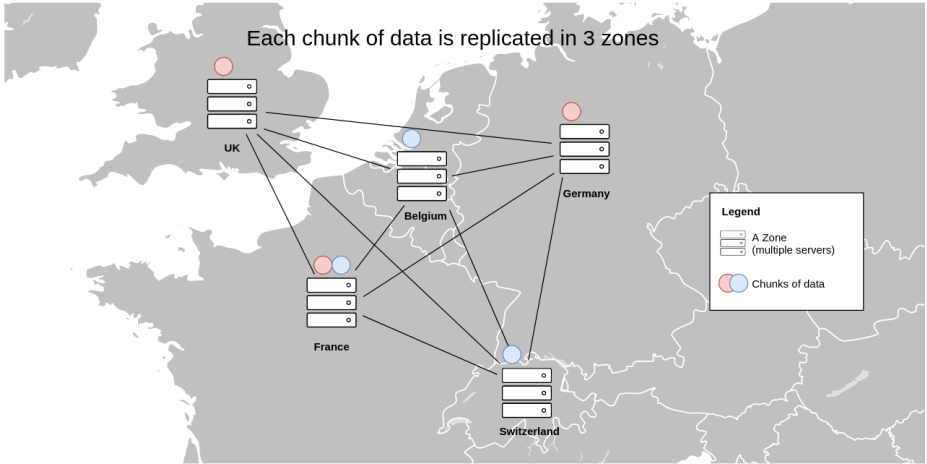

Fetching a file over Garage,
a simplified example
User
asks for a file
KEY
FILE
BLOCK 1
BLOCK 2
BLOCK 3
BLOCK 4
BLOCK 5
The descriptor is fetched
by hashing the key
From the descriptor,
we get the list of blocks
descriptor
BLOCK 4
BLOCK 3
BLOCK 2
[0x00, 0x5F]
BLOCK 5
BLOCK 4
BLOCK 2
BLOCK 1
[0x60, 0xBF]
descriptor
BLOCK 5
BLOCK 3
BLOCK 1
[0xC0, 0xFF]

Garage is *location-aware*

```
alex@io:~$ docker exec -ti garage /garage status
==== HEALTHY NODES ====
ID                Hostname   Address                          Tags                  Zone      Capacity
7d50f042280fea98  io         [2a01:e0a:5e4:1d0::57]:3901      [io,jupiter]          jupiter   20
d9b5959e58a3ab8c  drosera    [2a01:e0a:260:b5b0::4]:3901      [drosera,atuin]       atuin     20
966dfc7ed8049744  datura     [2a01:e0a:260:b5b0::2]:3901      [datura,atuin]        atuin     10
8cf284e7df17d0fd  celeri     [2a06:a004:3025:1::33]:3901      [celeri,neptune]      neptune   5
156d0f7a88b1e328  digitale   [2a01:e0a:260:b5b0::3]:3901      [digitale,atuin]      atuin     10
5fcb3b6e39db3dcb  concombre  [2a06:a004:3025:1::31]:3901      [concombre,neptune]   neptune   5
a717e5b618267806  courgette  [2a06:a004:3025:1::32]:3901      [courgette,neptune]   neptune   5
alex@io:~$
```

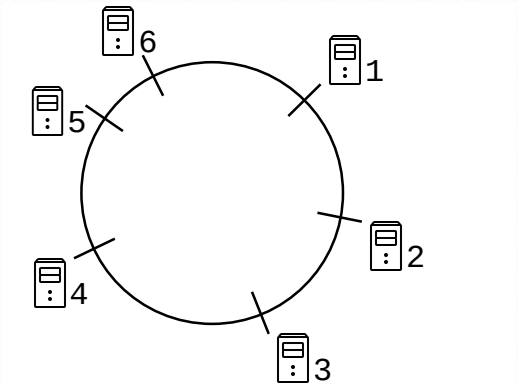
Garage replicates data on different zones when possible

Garage is *location-aware*



How to spread files over different cluster nodes?

Consistent hashing (DynamoDB):



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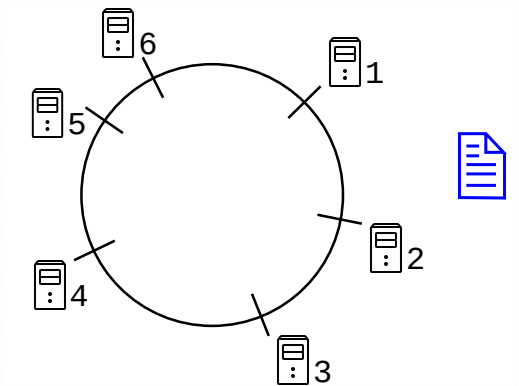

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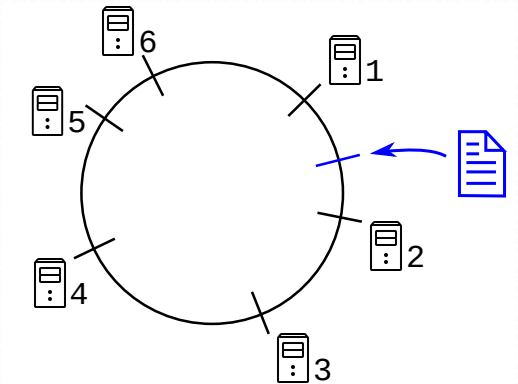

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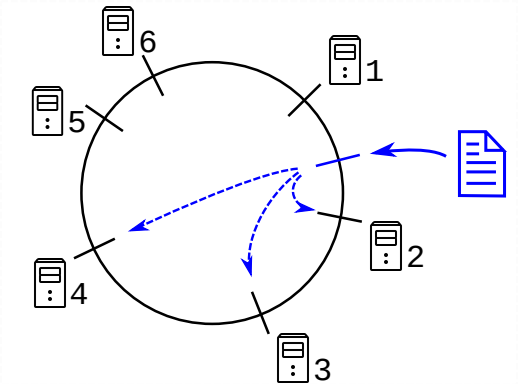

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Issues with consistent hashing:

- Doesn't dispatch data based on geographical location of nodes
- Geographically aware adaptation, try 1:
  data quantities not well balanced between nodes
- Geographically aware adaptation, try 2:
  too many reshuffles when adding/removing nodes

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Garage's method: build an index table

Realization: we can actually precompute an optimal solution

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Partition	**Node 1**	**Node 2**	**Node 3**
Partition 0	Io (jupiter)	Drosera (atuin)	Courgette (neptune)
Partition 1	Datura (atuin)	Courgette (neptune)	Io (jupiter)
Partition 2	Io(jupiter)	Celeri (neptune)	Drosera (atuin)
⋮	⋮	⋮	⋮
Partition 255	Concombre (neptune)	Io (jupiter)	Drosera (atuin)

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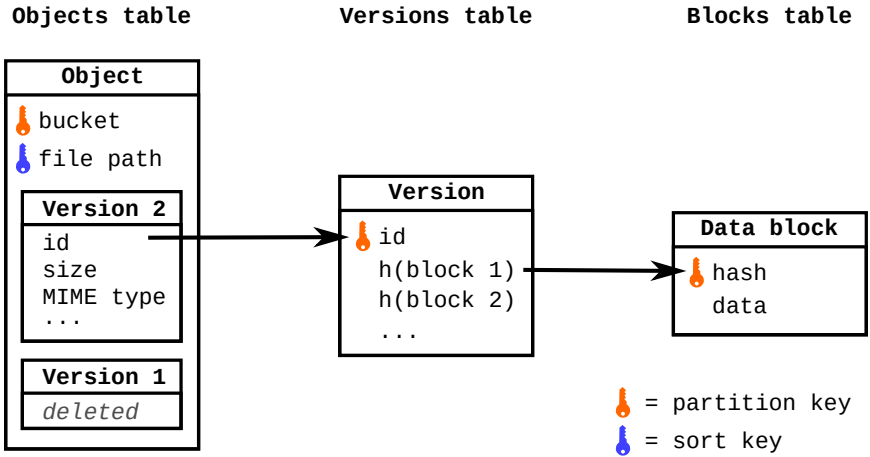
Partition 255	Concombre (neptune)	Io (jupiter)	Drosera (atuin)

The index table is built centrally using an optimal* algorithm,
then propagated to all nodes

*not yet optimal but will be soon

Garage's internal data structures



Garage is *coordination-free*:

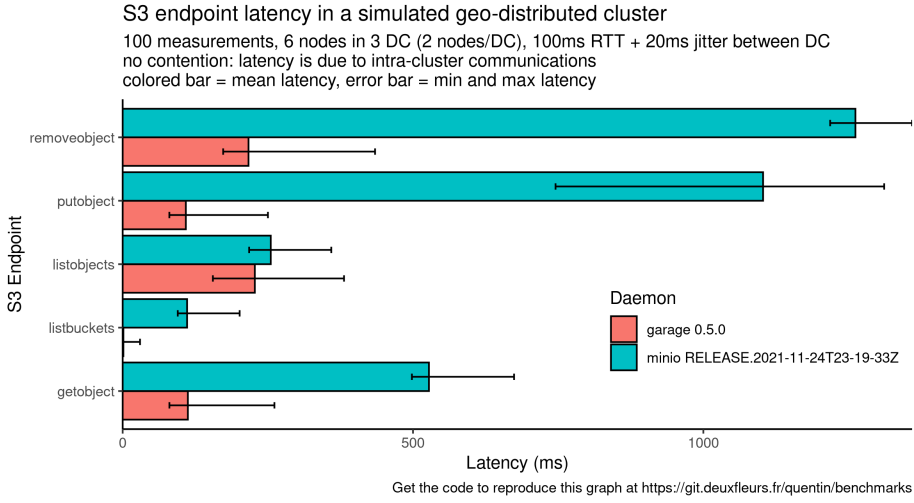
- No Raft or Paxos
- Internal data types are CRDTs
- All nodes are equivalent (no master/leader/index node)

$\rightarrow$ less sensitive to higher latencies between nodes

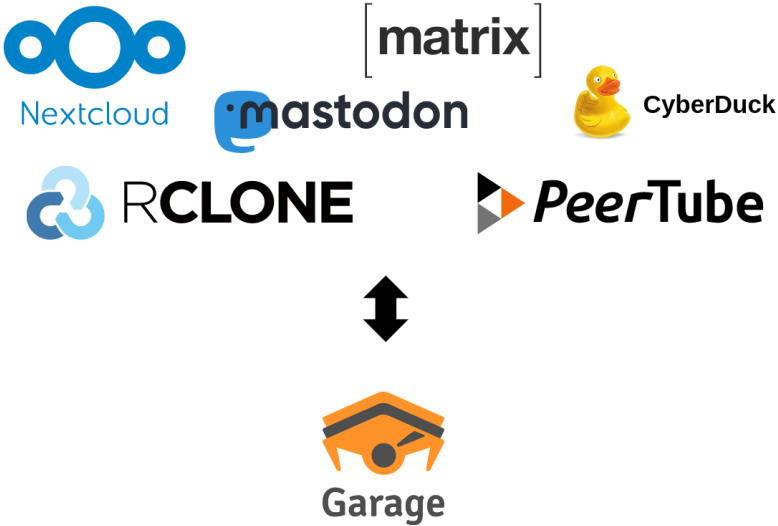
Consistency model

- Not ACID (not required by S3 spec) / not linearizable
- **Read-after-write consistency**
  (stronger than eventual consistency)

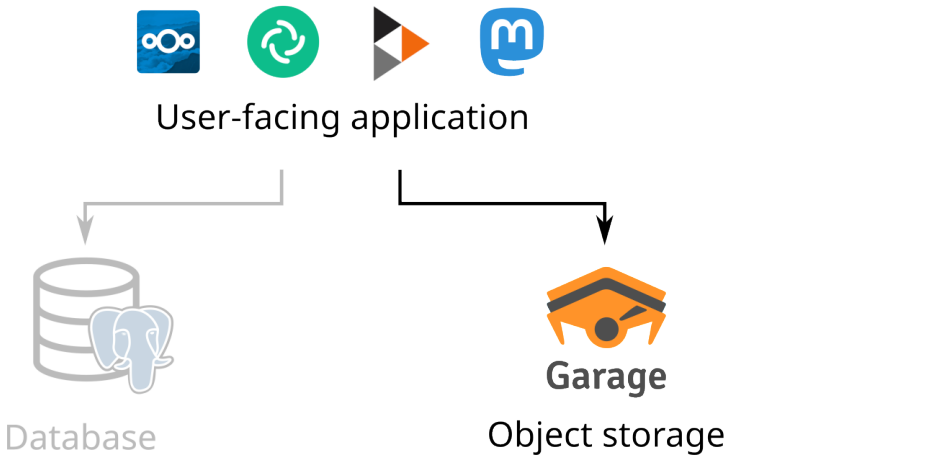
Impact on performances



An ever-increasing compatibility list



Further plans for Garage



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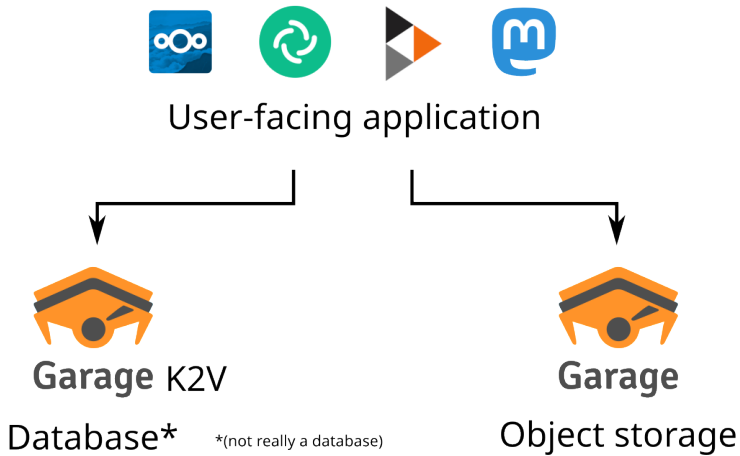

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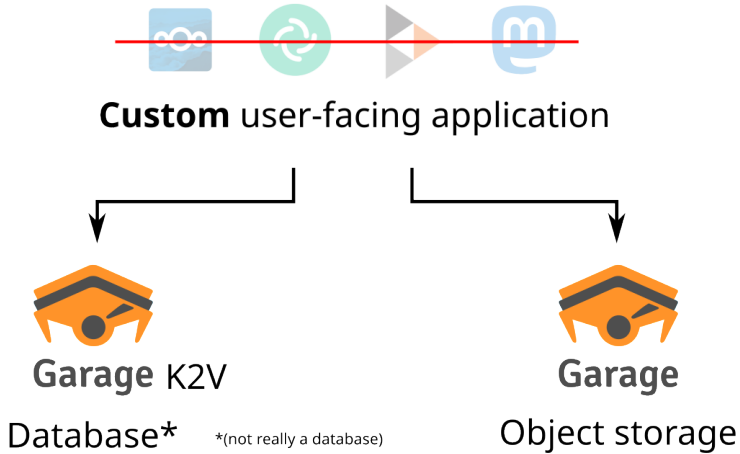

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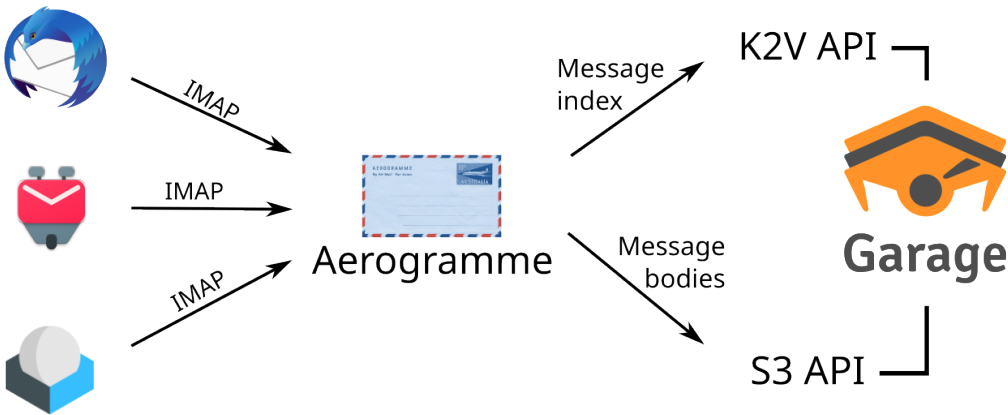
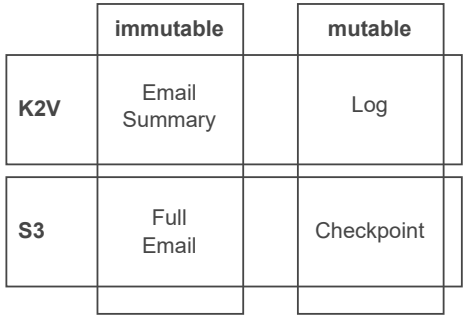
- A new, custom, minimal API
- Exposes the partitoning mechanism of Garage
  K2V = partition key / sort key / value (like Dynamo)
- Coordination-free, CRDT-friendly (inspired by Riak)
- Cryptography-friendly: values are binary blobs

Application: an e-mail storage server



Aerogramme data model



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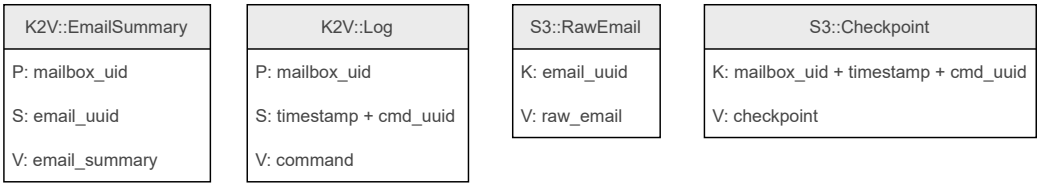


Aerogramme data model

K2V::EmailSummary
P: mailbox_uid
S: email_uuid
V: email_summary

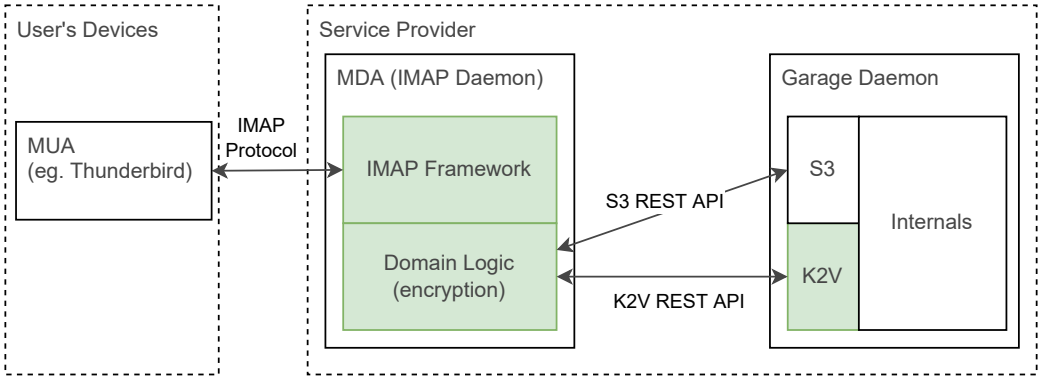
K2V::Log
P: mailbox_uid
S: timestamp + cmd_uuid
V: command

S3::RawEmail
K: email_uuid
V: raw_email

S3::Checkpoint
K: mailbox_uid + timestamp + cmd_uuid
V: checkpoint

Aerogramme encrypts all stored values for privacy
(Garage server administrators can't read your mail)

Different deployment scenarios



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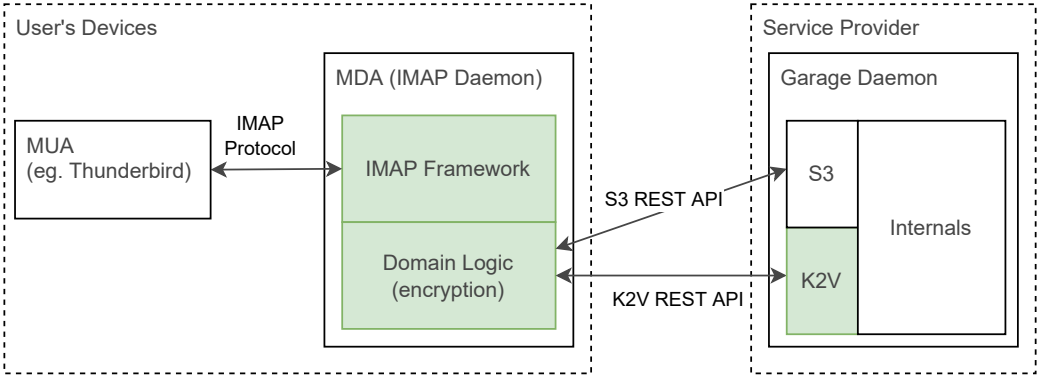

A new model for building resilient software

- Design a data model suited to K2V
  (see Cassandra docs on porting SQL data models to Cassandra)
  - Use CRDTs or other eventually consistent data types (see e.g. Bayou)
  - Store opaque binary blobs to provide End-to-End Encryption
- Store big blobs (files) in S3
- Let Garage manage sharding, replication, failover, etc.

Research perspectives

- Write about Garage's global architecture *(paper in progress)*
- Measure and improve Garage's performances
- Discuss the optimal layout algorithm, provide proofs
- Write about our proposed architecture for (E2EE) apps over K2V+S3

Where to find us

Garage

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#garage:deuxfleurs.fr on Matrix