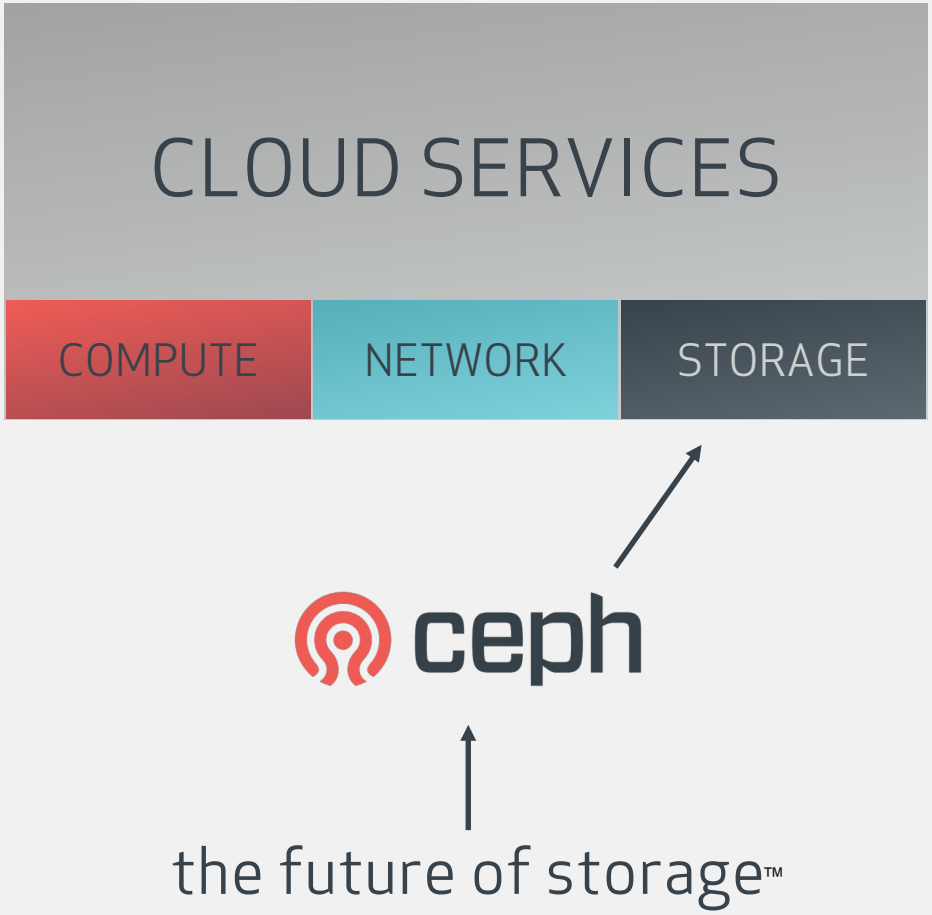
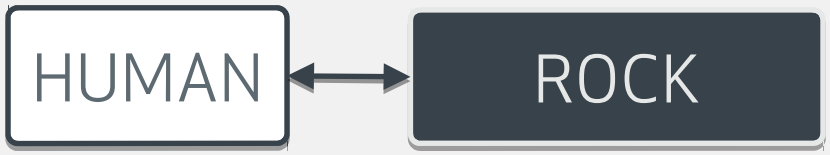
# Software Defined Storage: What Makes Ceph Unique

Federico Lucifredi
Product Management Director, Ceph Storage
Boston/Guadalajara, December 14th, 2015


CLOUD SERVICES
COMPUTE
NETWORK
STORAGE
ceph
the future of storage™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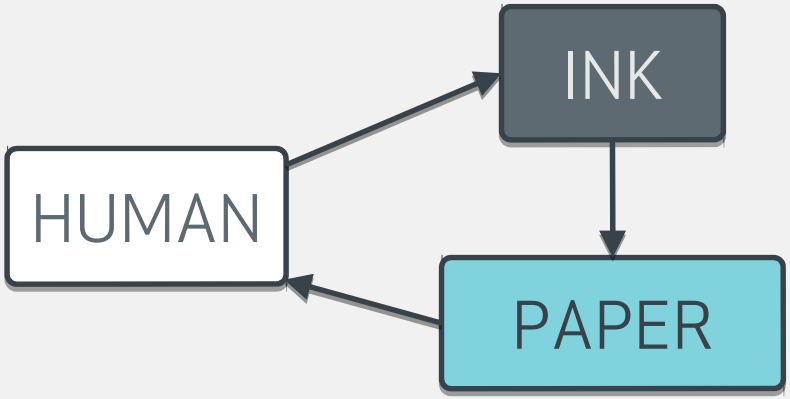
INK
HUMAN
PAPER


HUMAN
COMPUTER
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COMPUTER
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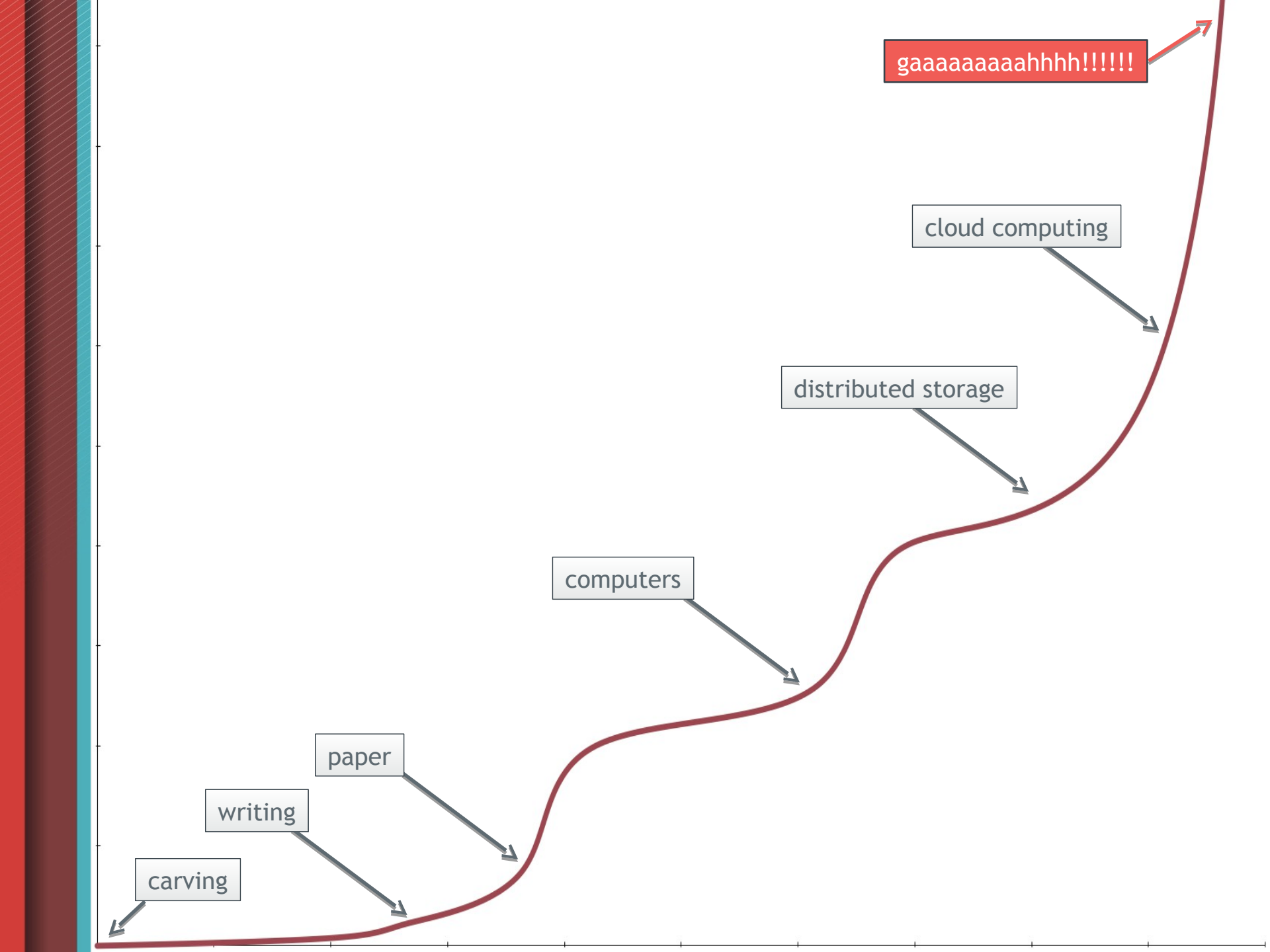
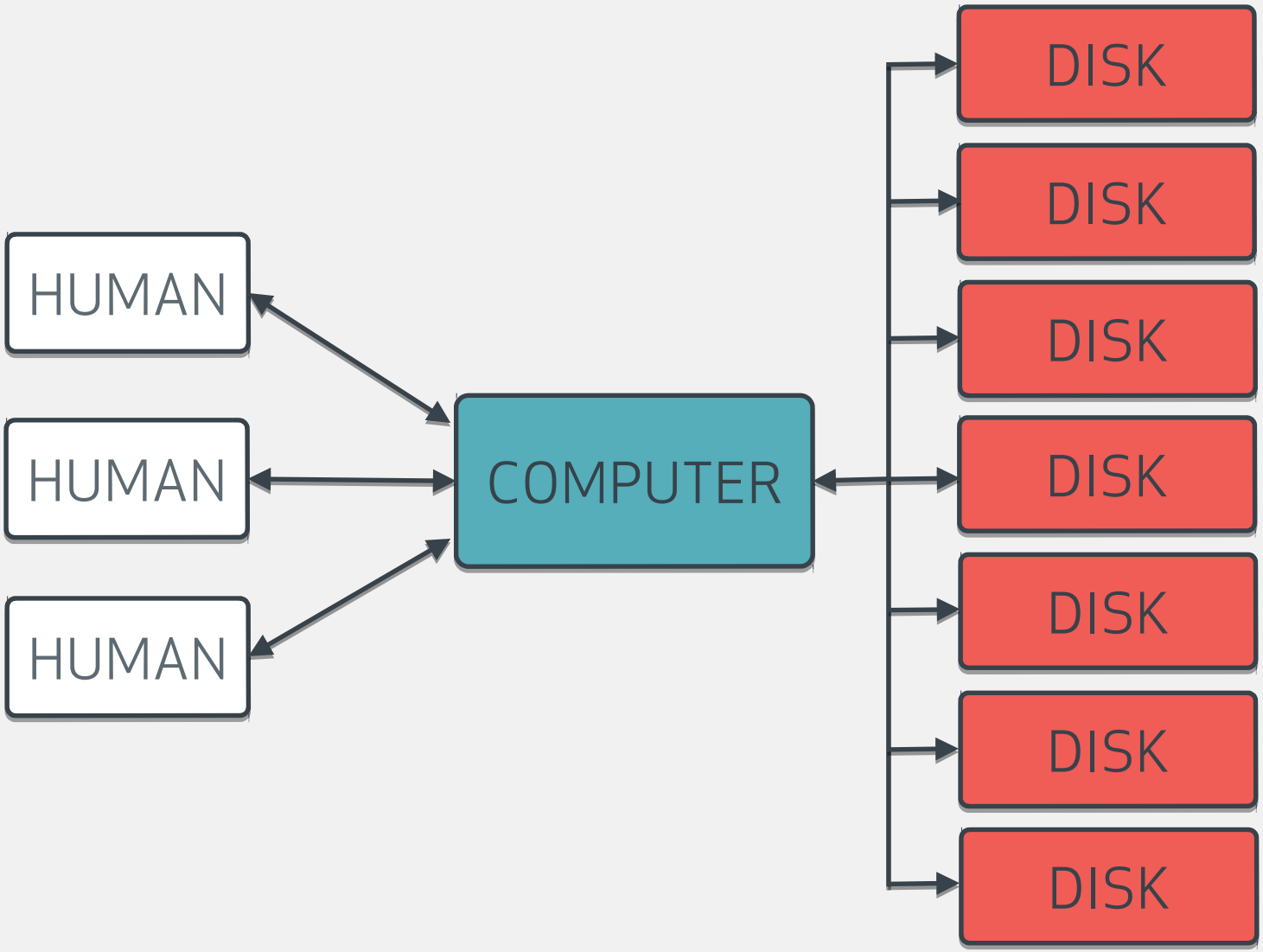
YOU
TECHNOLOGY
YOUR DATA


gaaaaaaaaahhhh!!!!!!
cloud computing
distributed storage
computers
paper
writing
carving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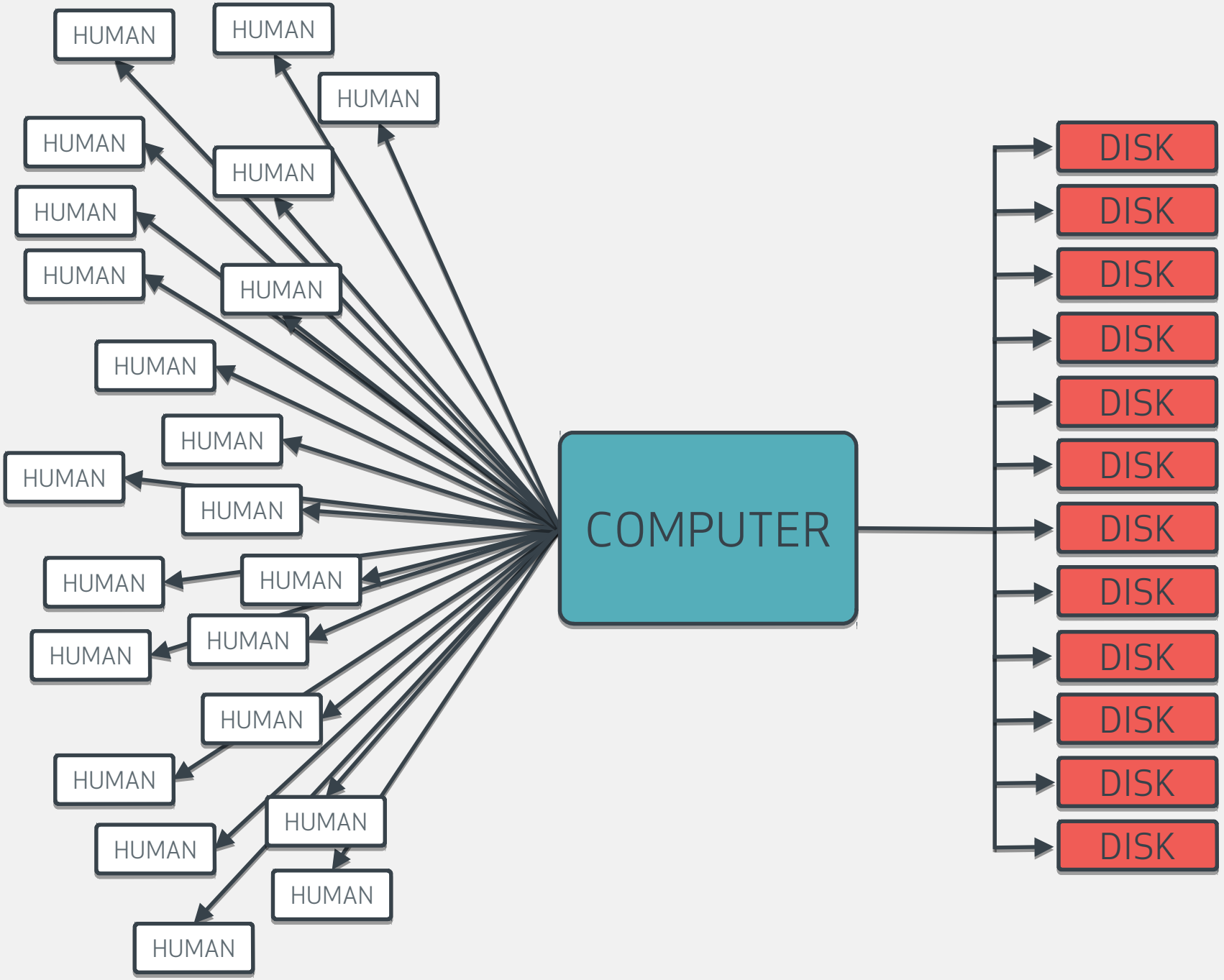
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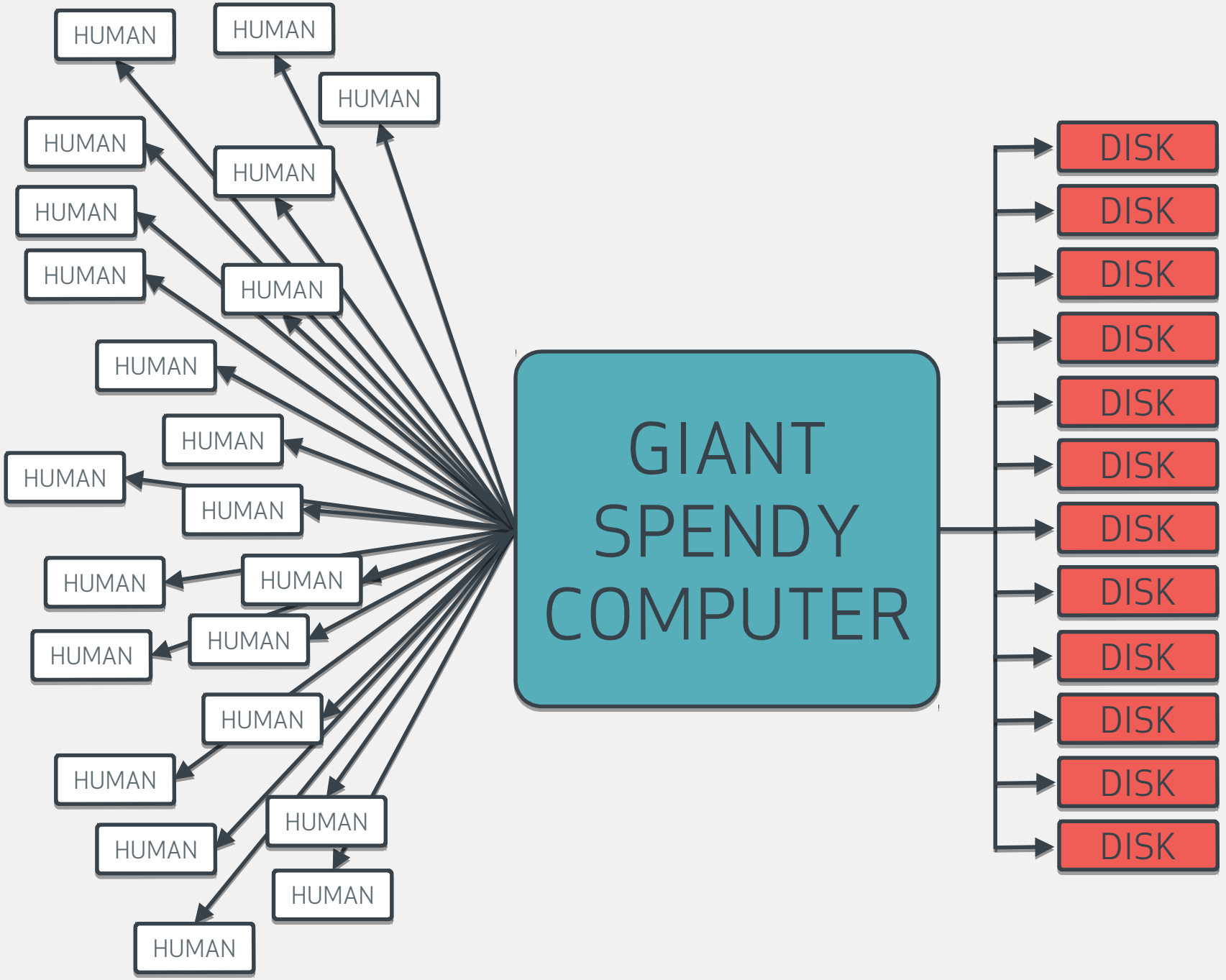
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GIANT SPENDY COMPUTER
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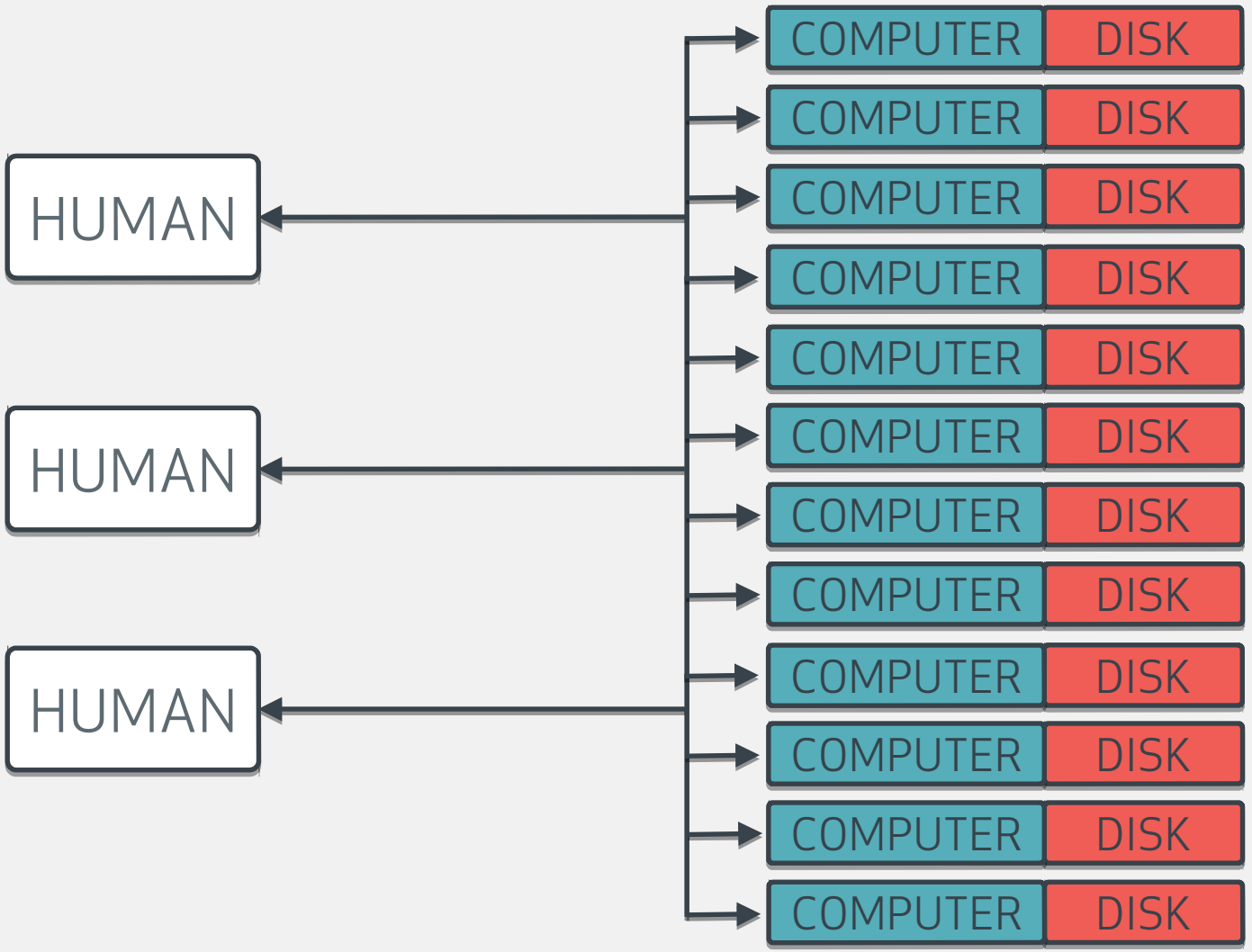
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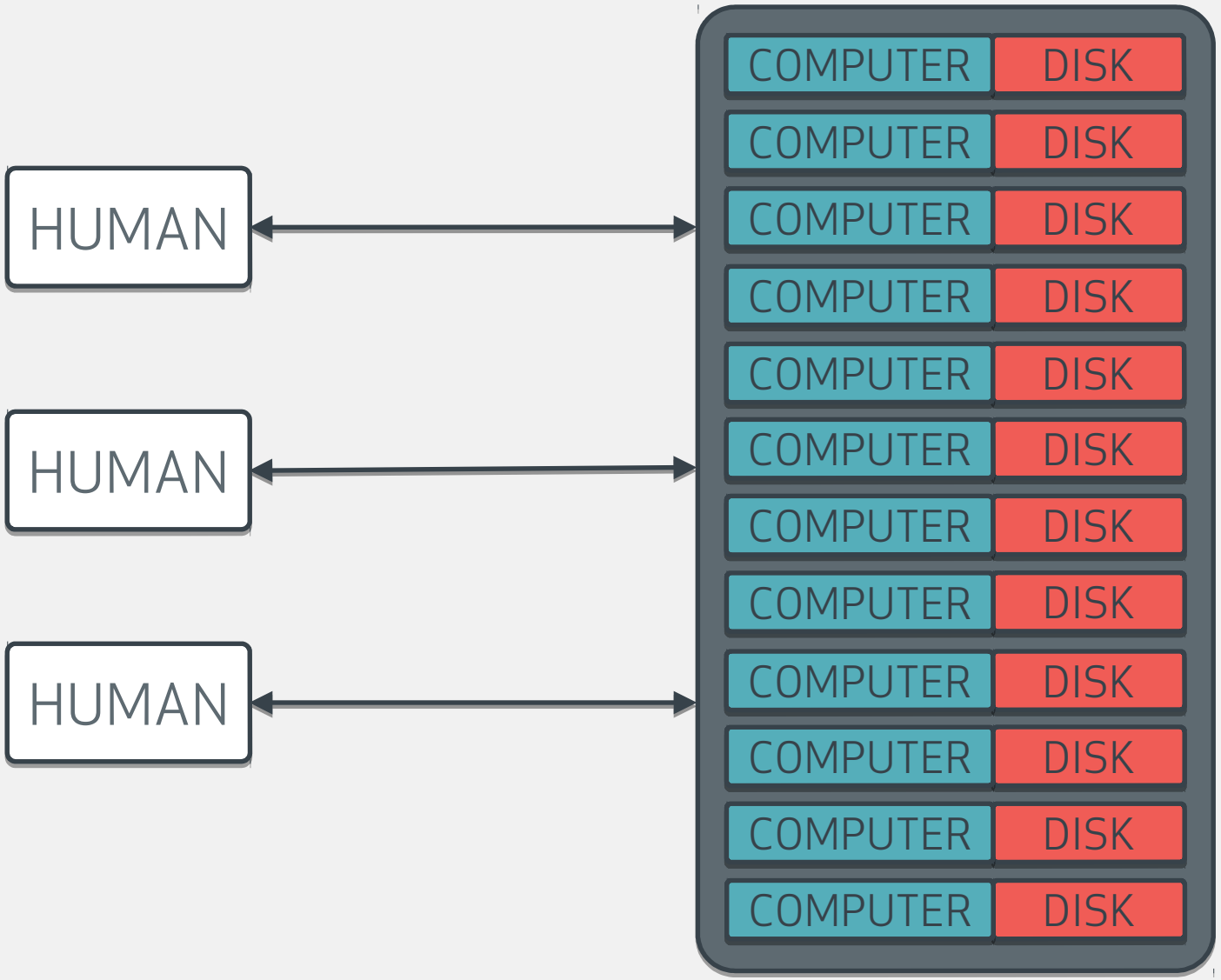
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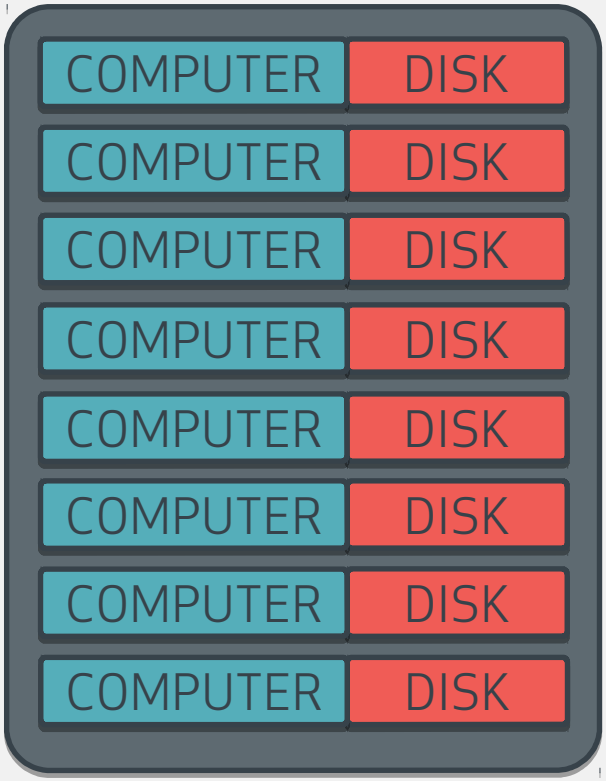
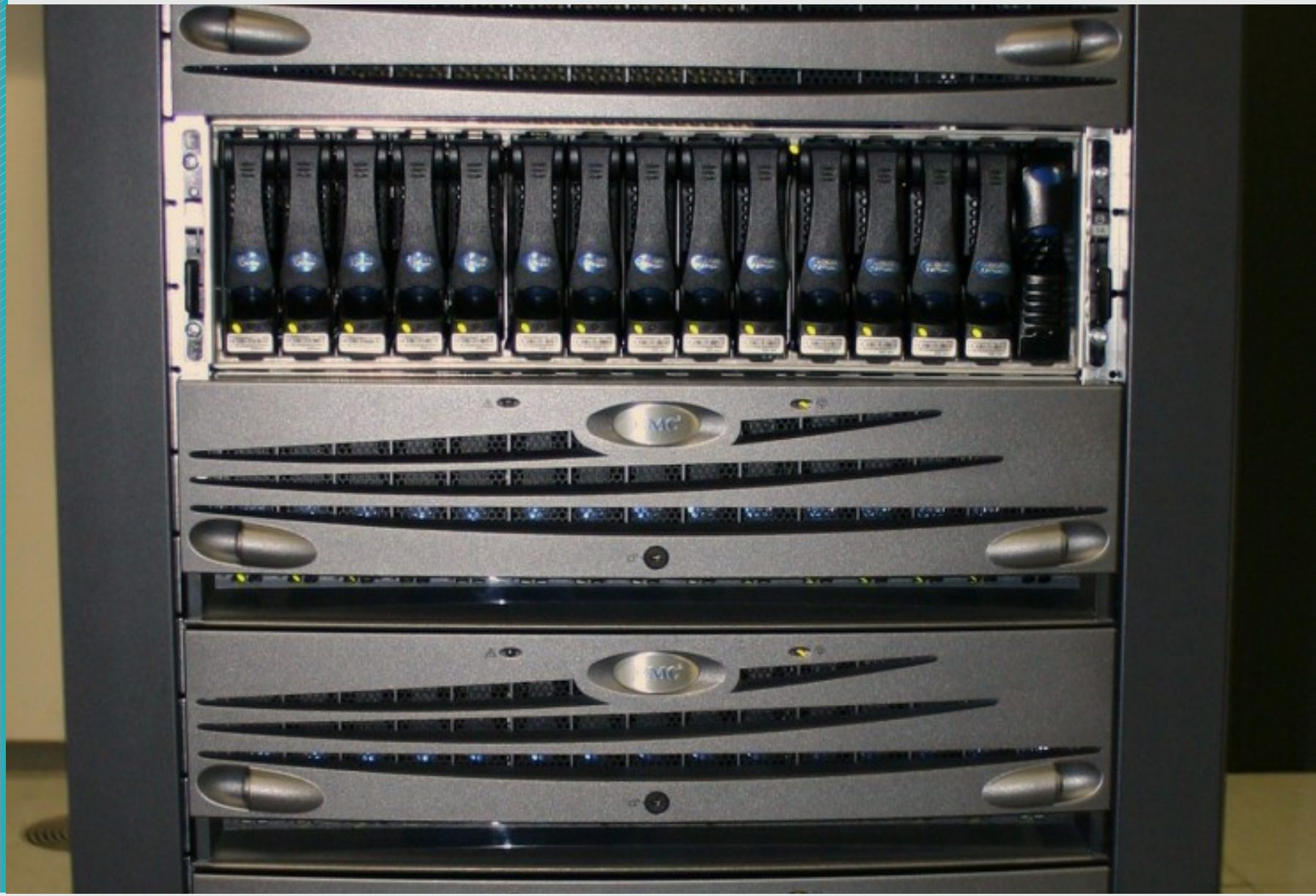
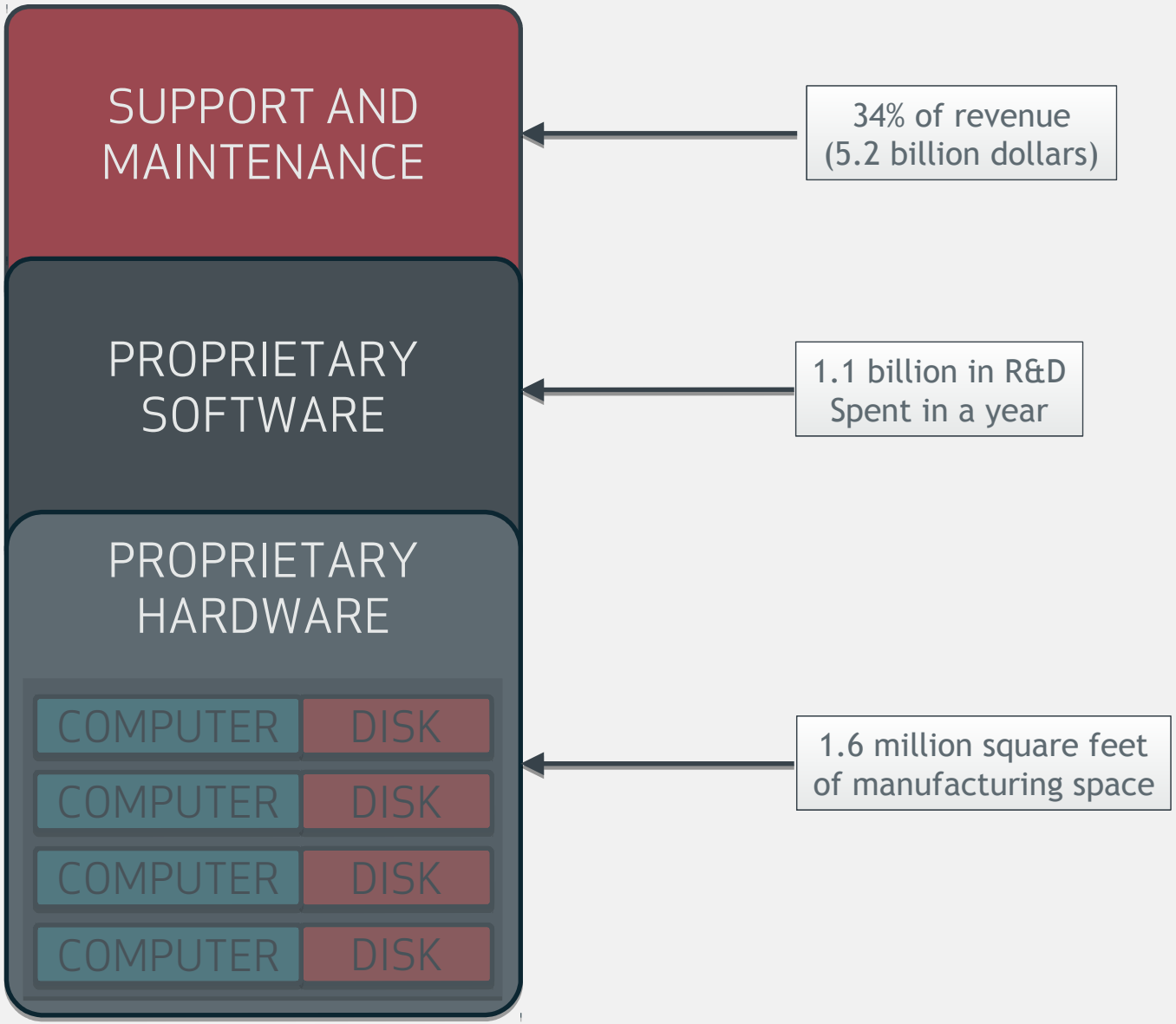
# “STORAGE APPLIANCE”

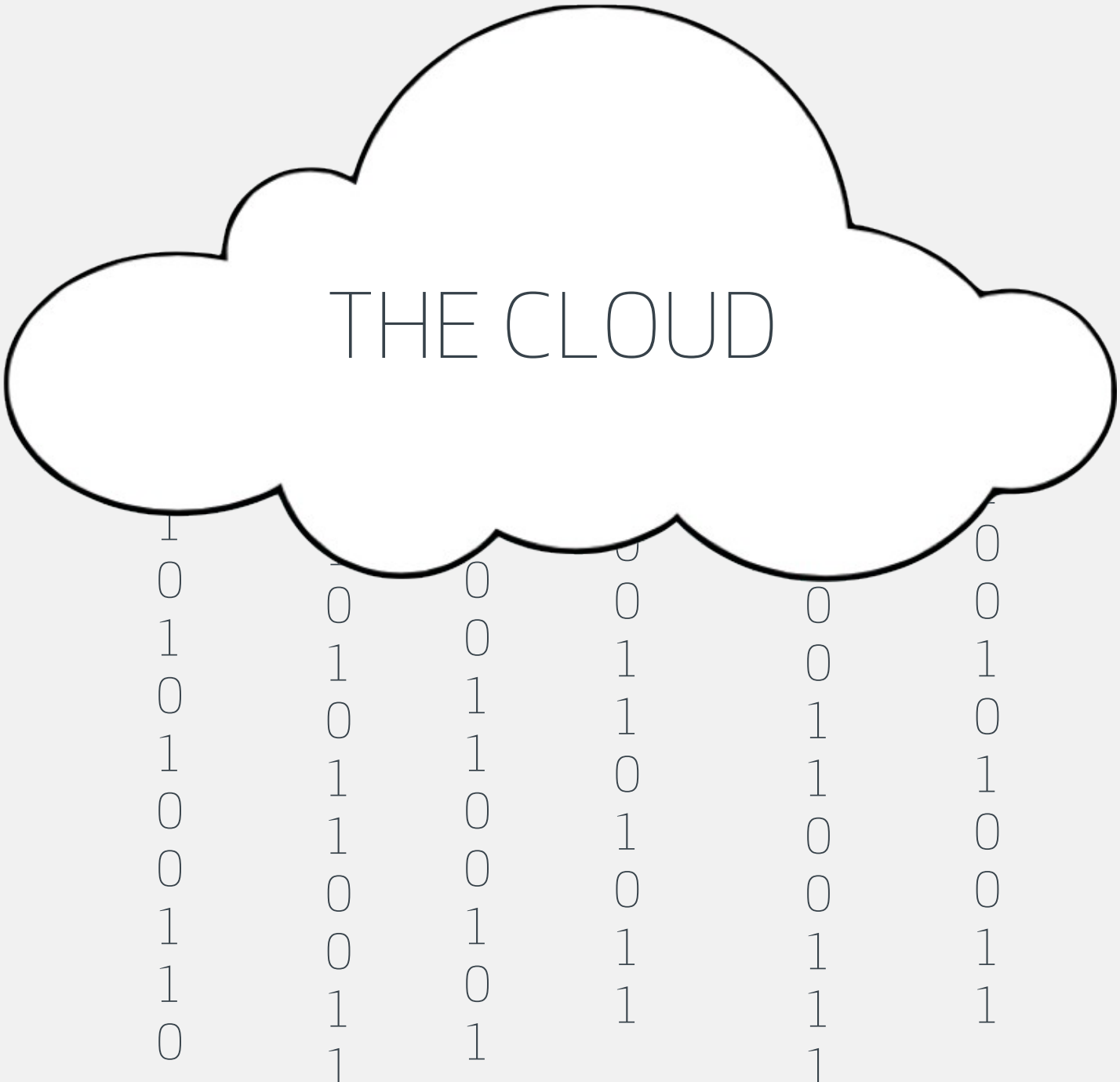


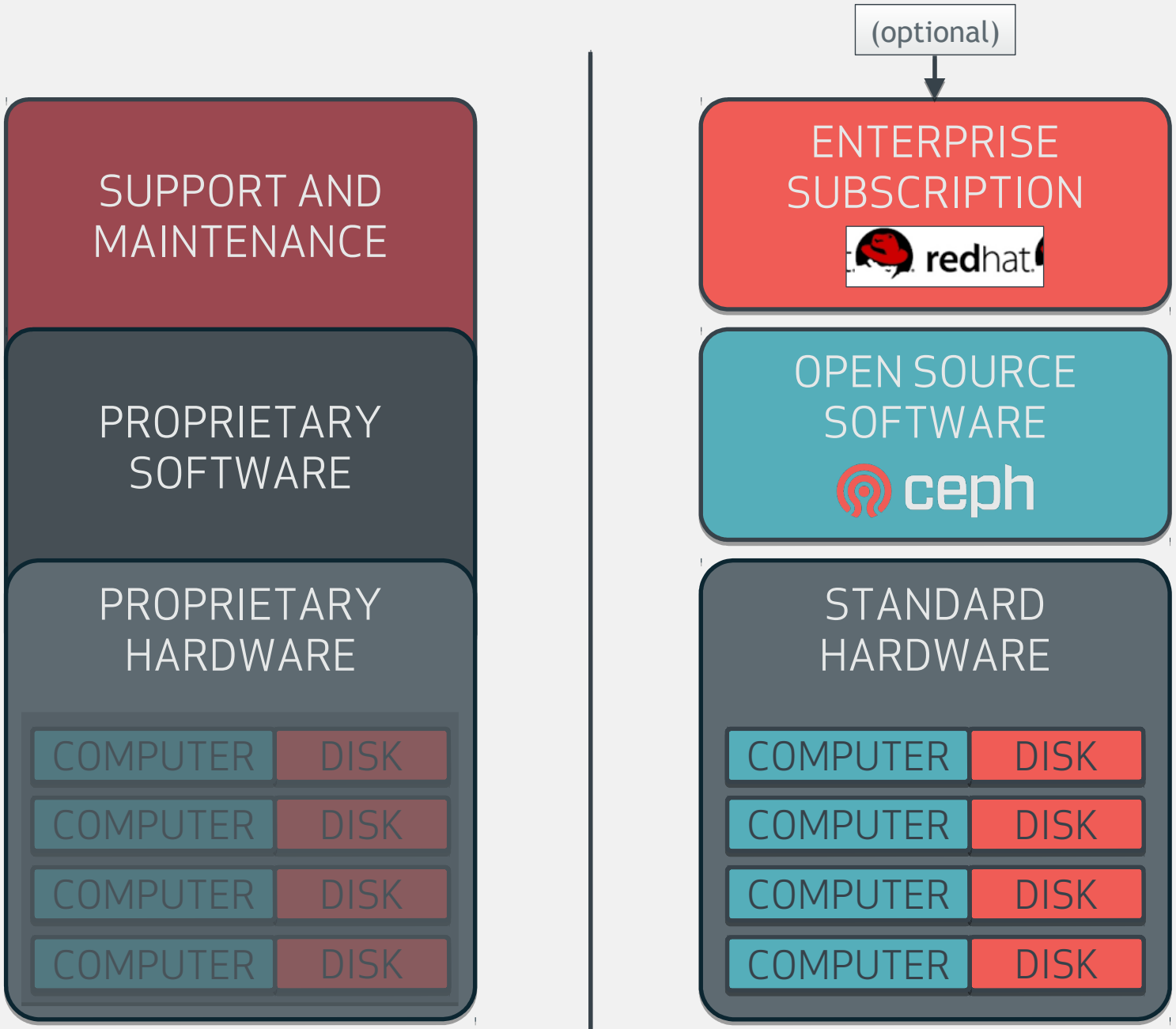


## Storage Appliance

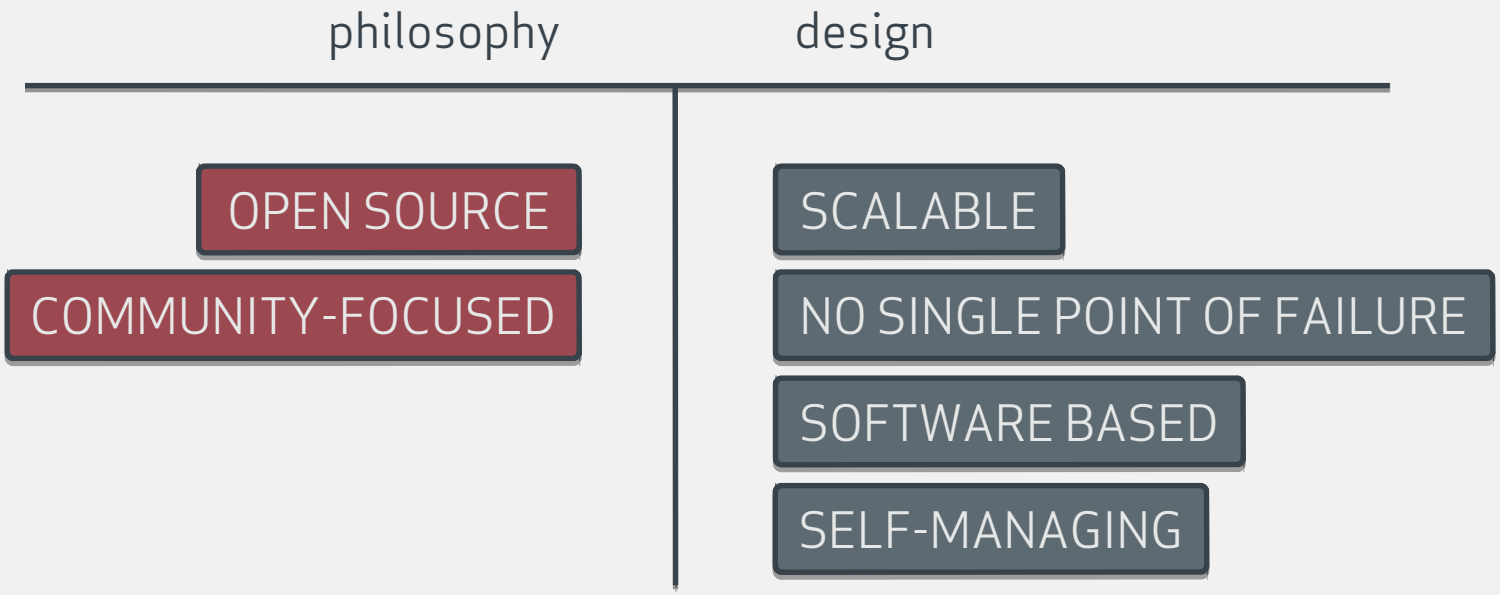
Michael Moll, Wikipedia / CC BY-SA 2.0

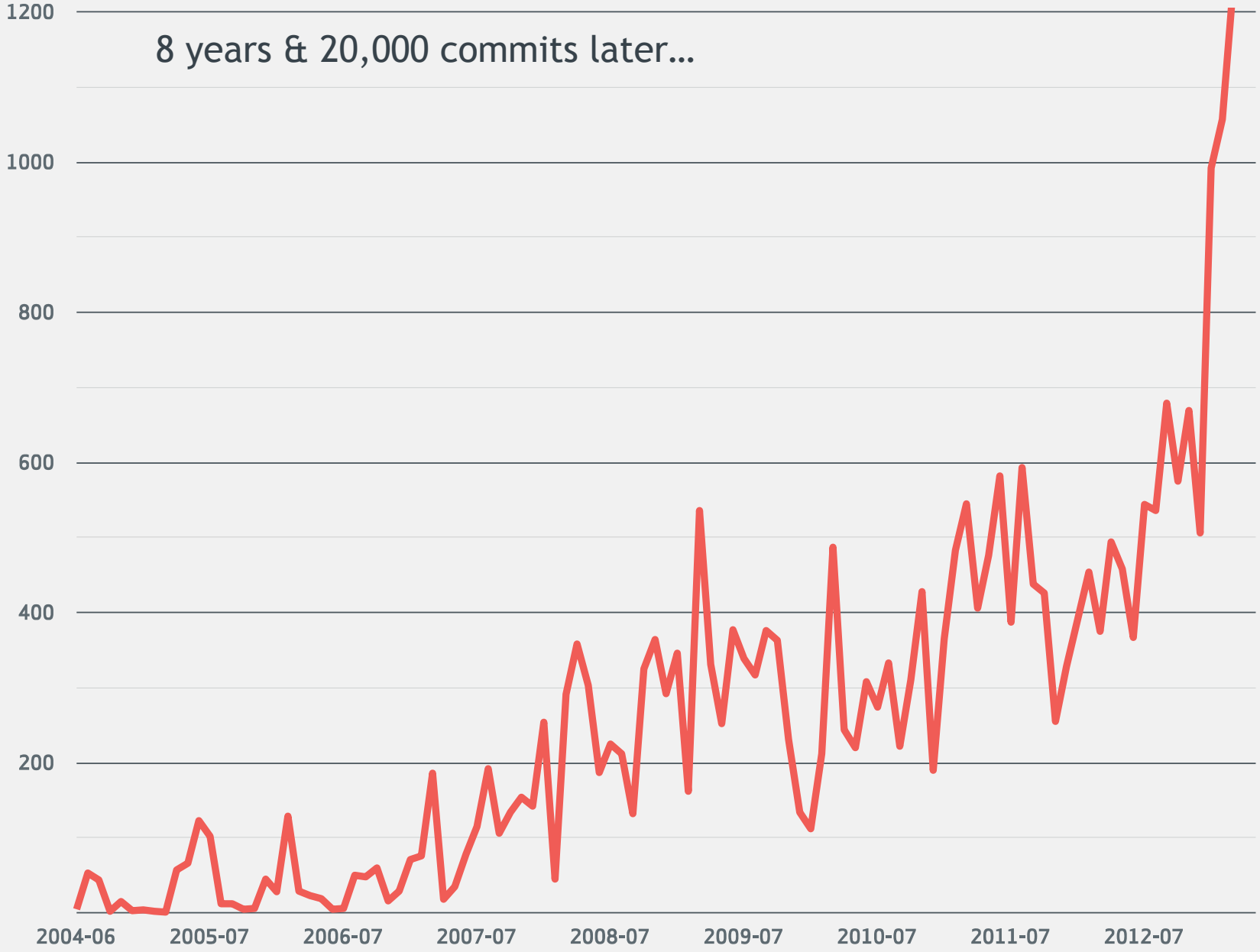

SUPPORT AND MAINTENANCE
PROPRIETARY SOFTWARE
PROPRIETARY HARDWARE
COMPUTER
DISK
COMPUTER
DISK
COMPUTER
DISK
COMPUTER
DISK
34% of revenue (5.2 billion dollars)
1.1 billion in R&D Spent in a year
1.6 million square feet of manufacturing space

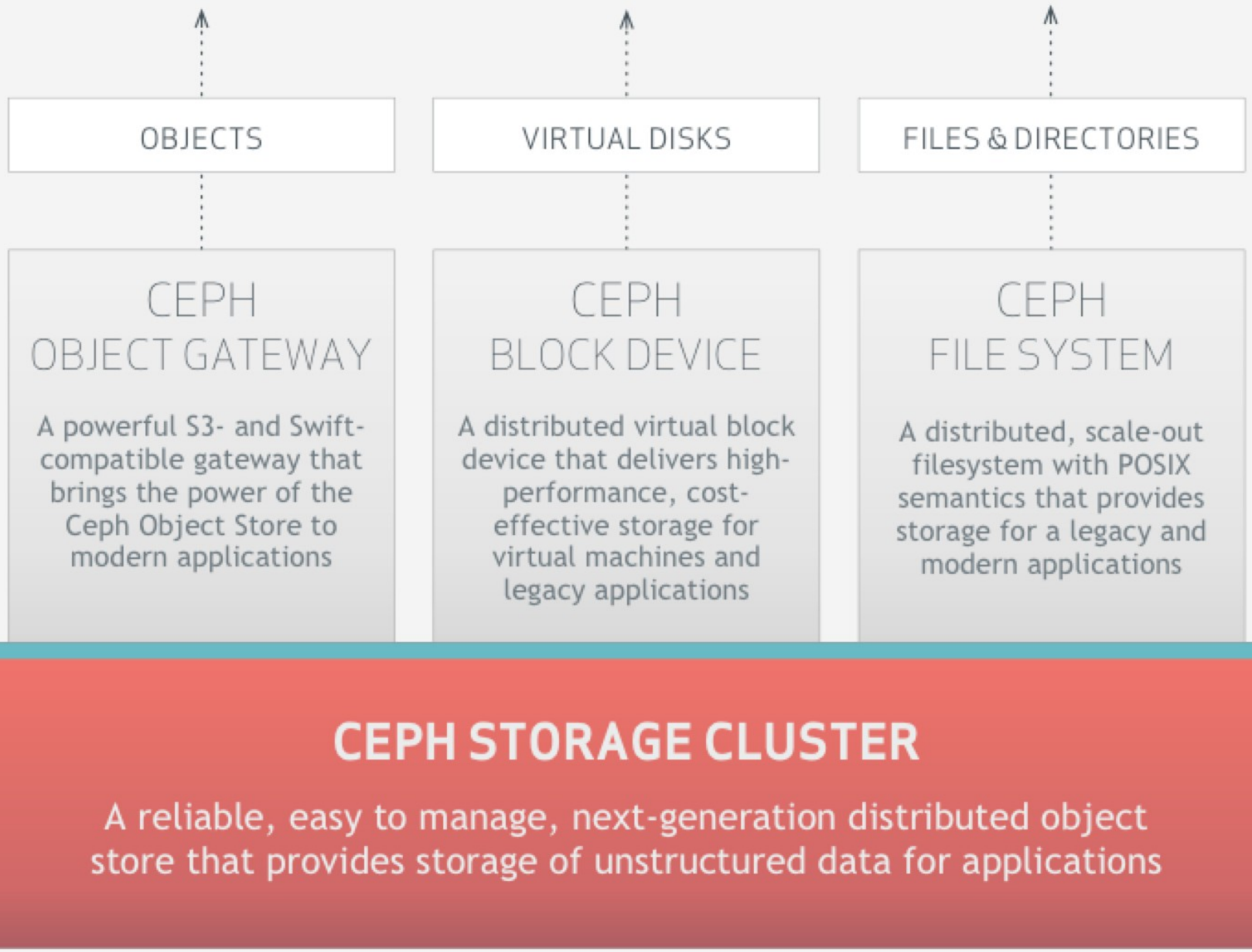

THE CLOUD

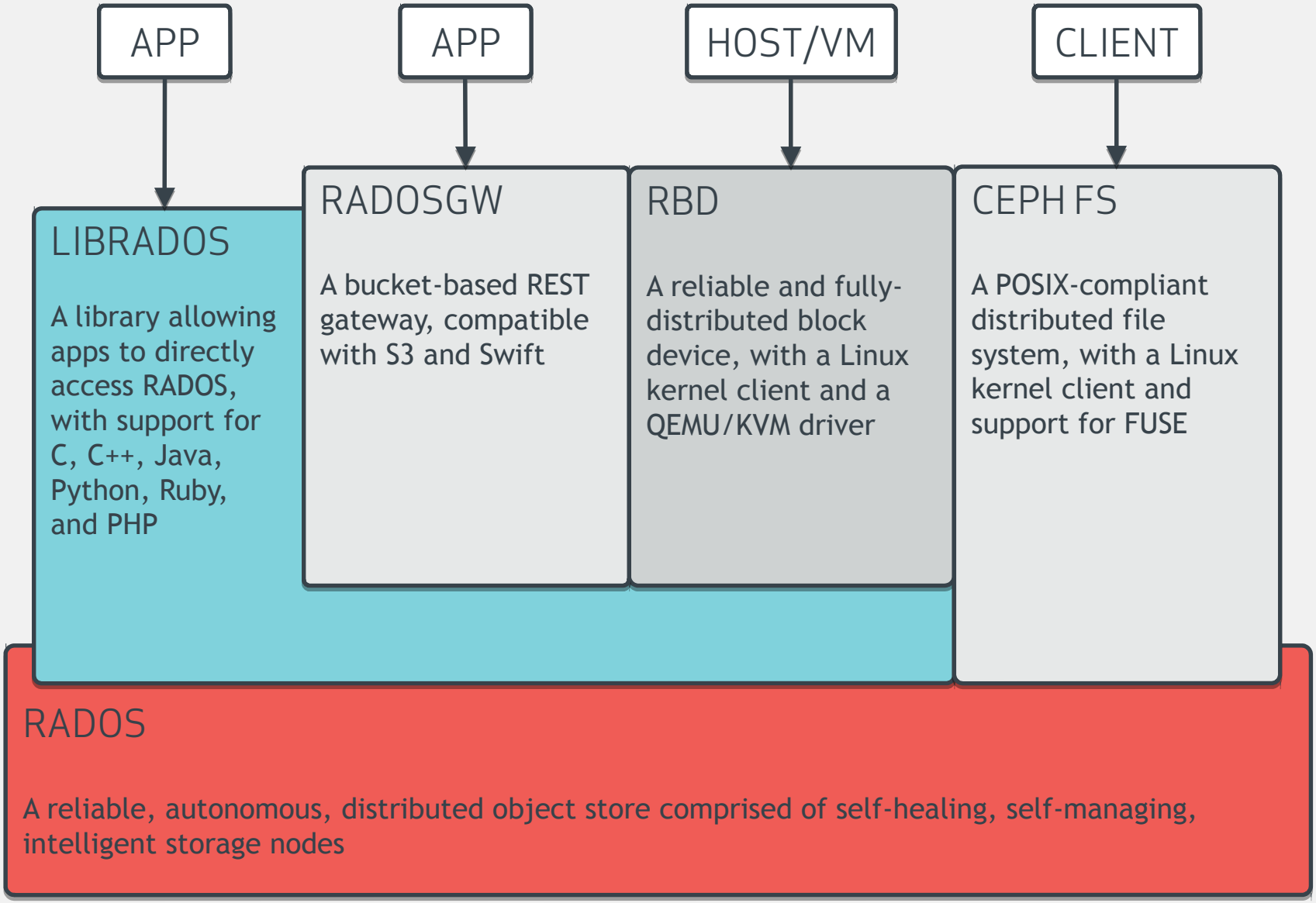

SUPPORT AND MAINTENANCE
PROPRIETARY SOFTWARE
PROPRIETARY HARDWARE
COMPUTER
DISK
COMPUTER
DISK
COMPUTER
DISK
COMPUTER
DISK
(optional)
ENTERPRISE SUBSCRIPTION
redhat.
OPEN SOURCE SOFTWARE
ceph
STANDARD HARDWARE
COMPUTER
DISK
COMPUTER
DISK
COMPUTER
DISK
COMPUTER
DISK

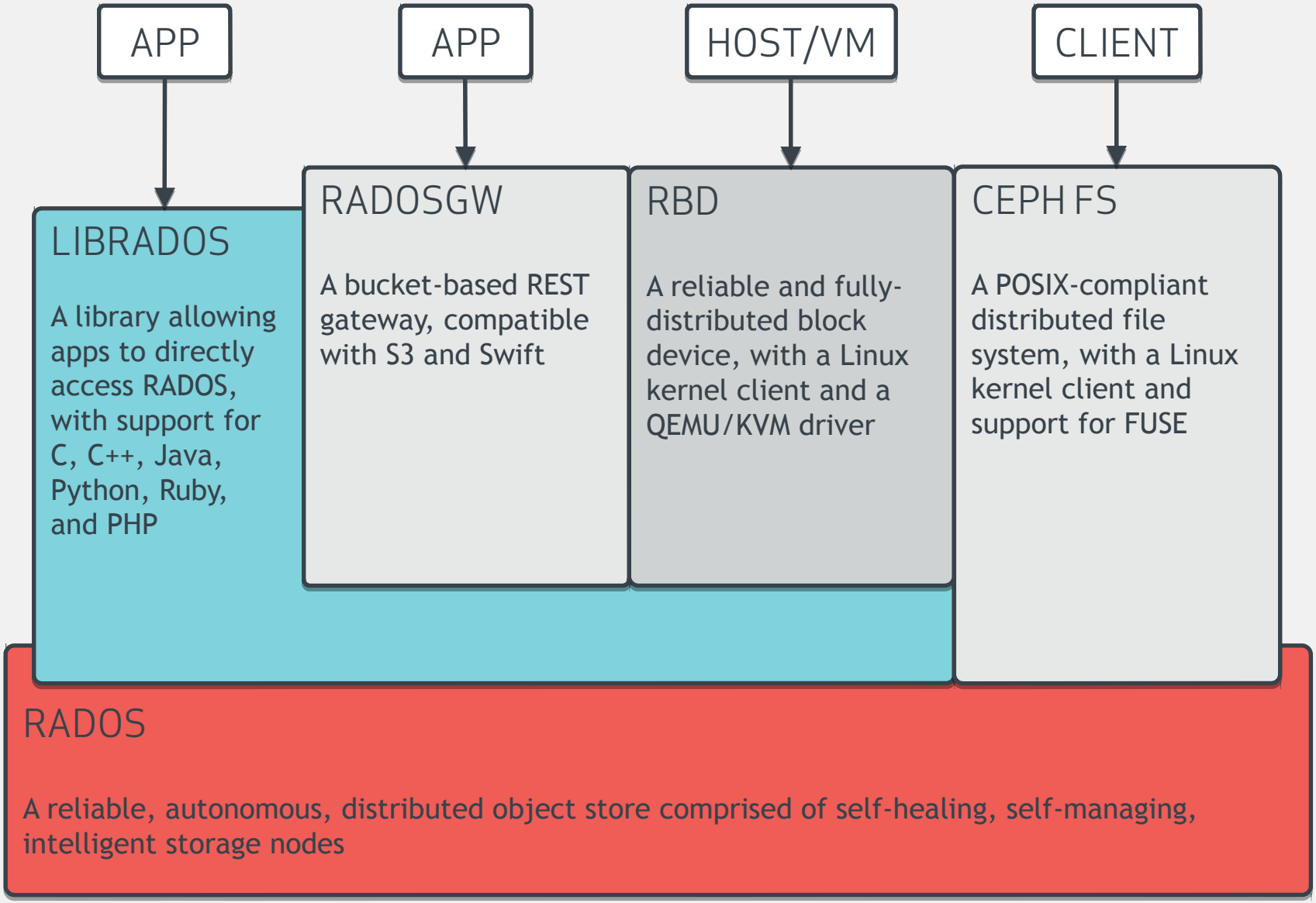

ceph


philosophy
design
OPEN SOURCE
COMMUNITY-FOCUSED
SCALABLE
NO SINGLE POINT OF FAILURE
SOFTWARE BASED
SELF-MANAGING


8 years & 20,000 commits later…
1200
1000
800
600
400
200
2004-06
2005-07
2006-07
2007-07
2008-07
2009-07
2010-07
2011-07
2012-07


OBJECTS
VIRTUAL DISKS
FILES & DIRECTORIES
CEPH
OBJECT GATEWAY
A powerful S3- and Swift-compatible gateway that brings the power of the Ceph Object Store to modern applications
CEPH
BLOCK DEVICE
A distributed virtual block device that delivers high-performance, cost-effective storage for virtual machines and legacy applications
CEPH
FILE SYSTEM
A distributed, scale-out filesystem with POSIX semantics that provides storage for a legacy and modern applications
CEPH STORAGE CLUSTER
A reliable, easy to manage, next-generation distributed object store that provides storage of unstructured data for applications


APP
APP
HOST/VM
CLIENT
LIBRADOS
A library allowing apps to directly access RADOS, with support for C, C++, Java, Python, Ruby, and PHP
RADOSGW
A bucket-based REST gateway, compatible with S3 and Swift
RBD
A reliable and fully-distributed block device, with a Linux kernel client and a QEMU/KVM driver
CEPH FS
A POSIX-compliant distributed file system, with a Linux kernel client and support for FUSE
RADOS
A reliable, autonomous, distributed object store comprised of self-healing, self-managing, intelligent storage nodes


APP
APP
HOST/VM
CLIENT
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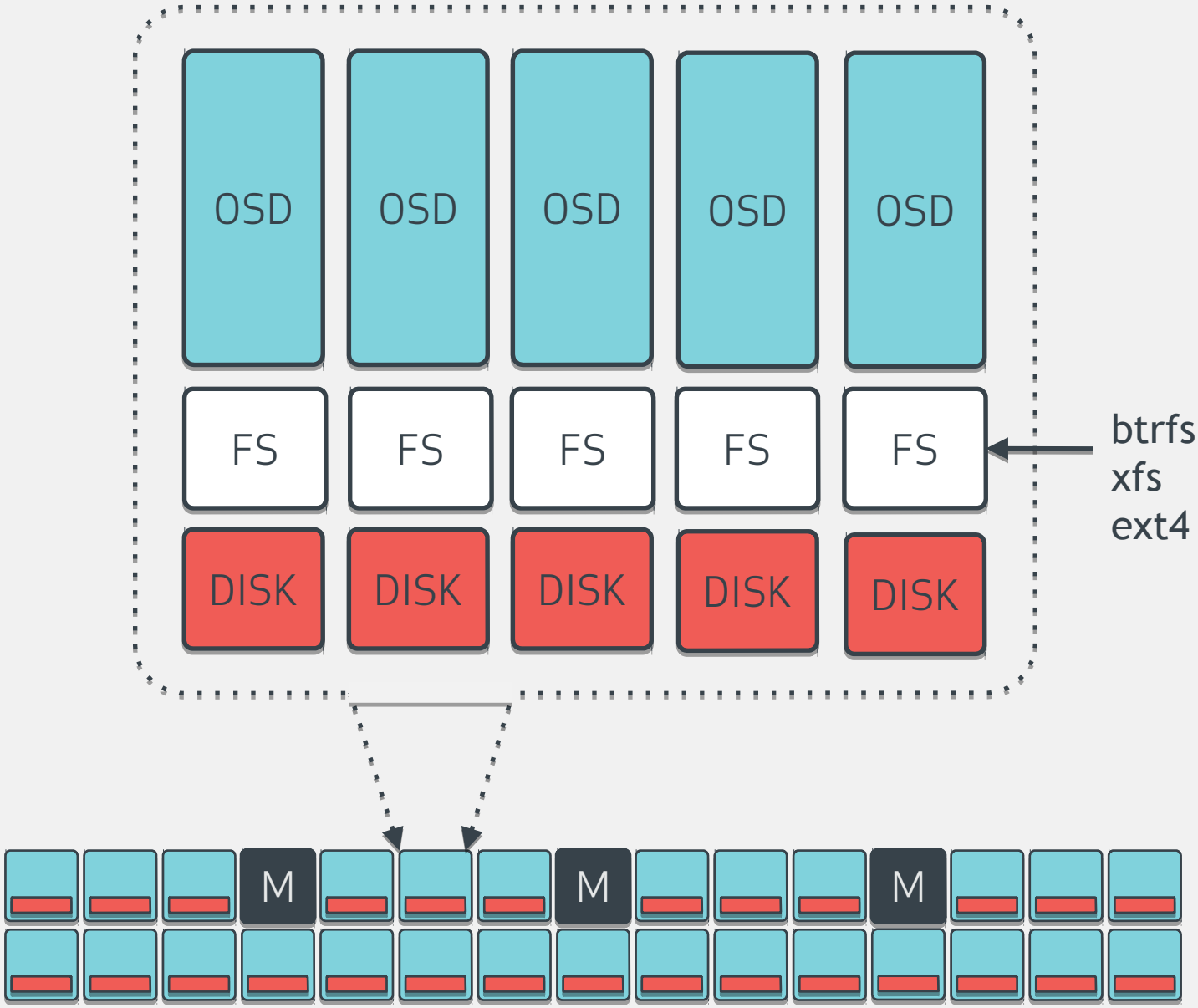
OSD
OSD
OSD
OSD
OSD
FS
FS
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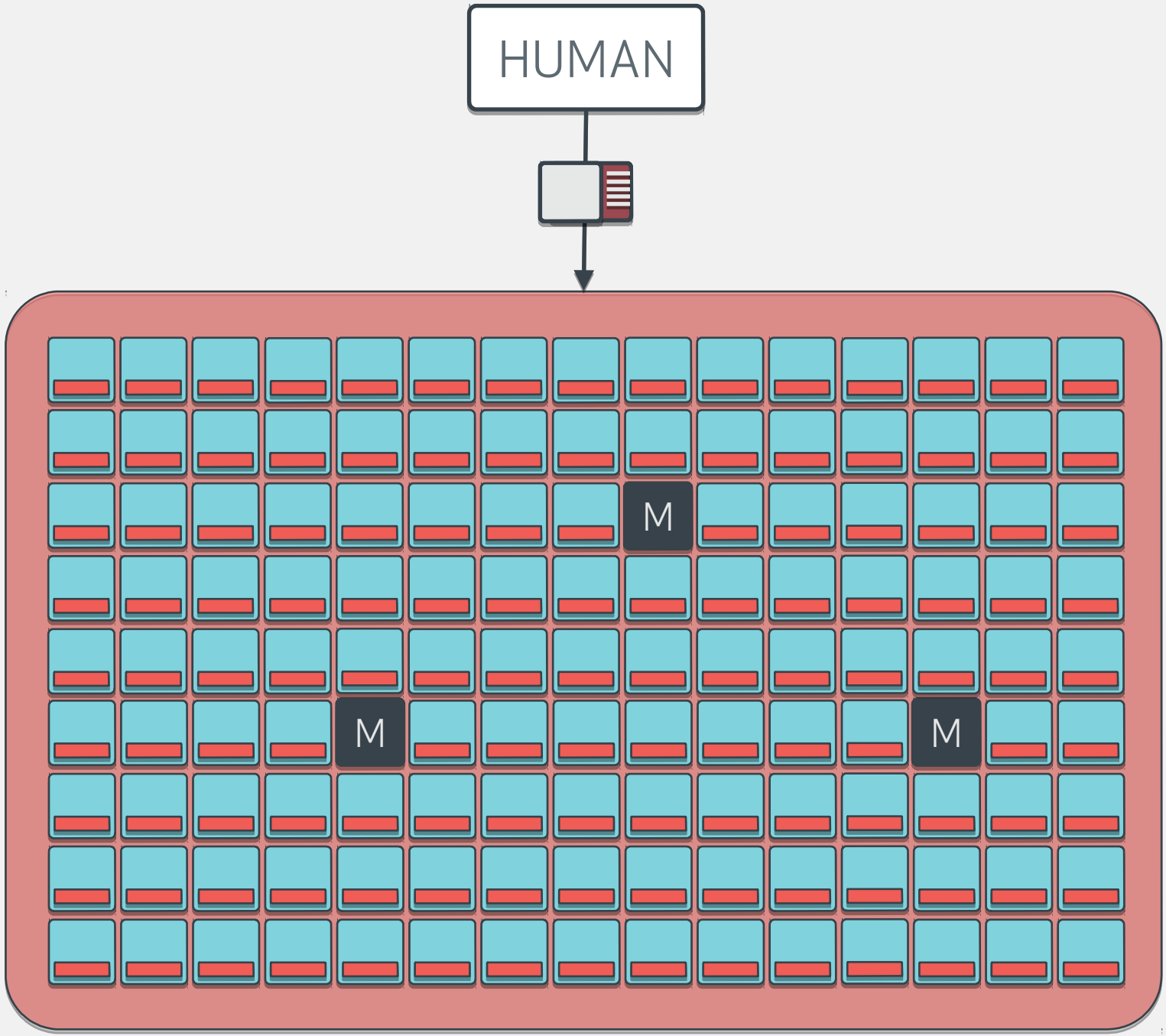
FS
FS
DISK
DISK
DISK
DISK
DISK
btrfs
xfs
ext4
M
M
M


HUMAN
M
M
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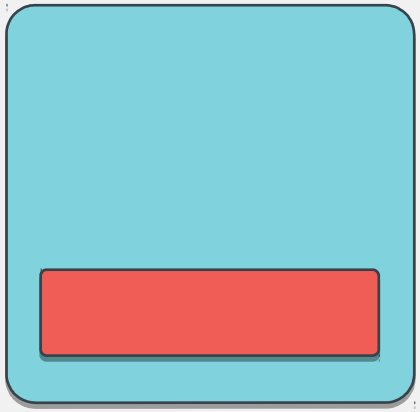
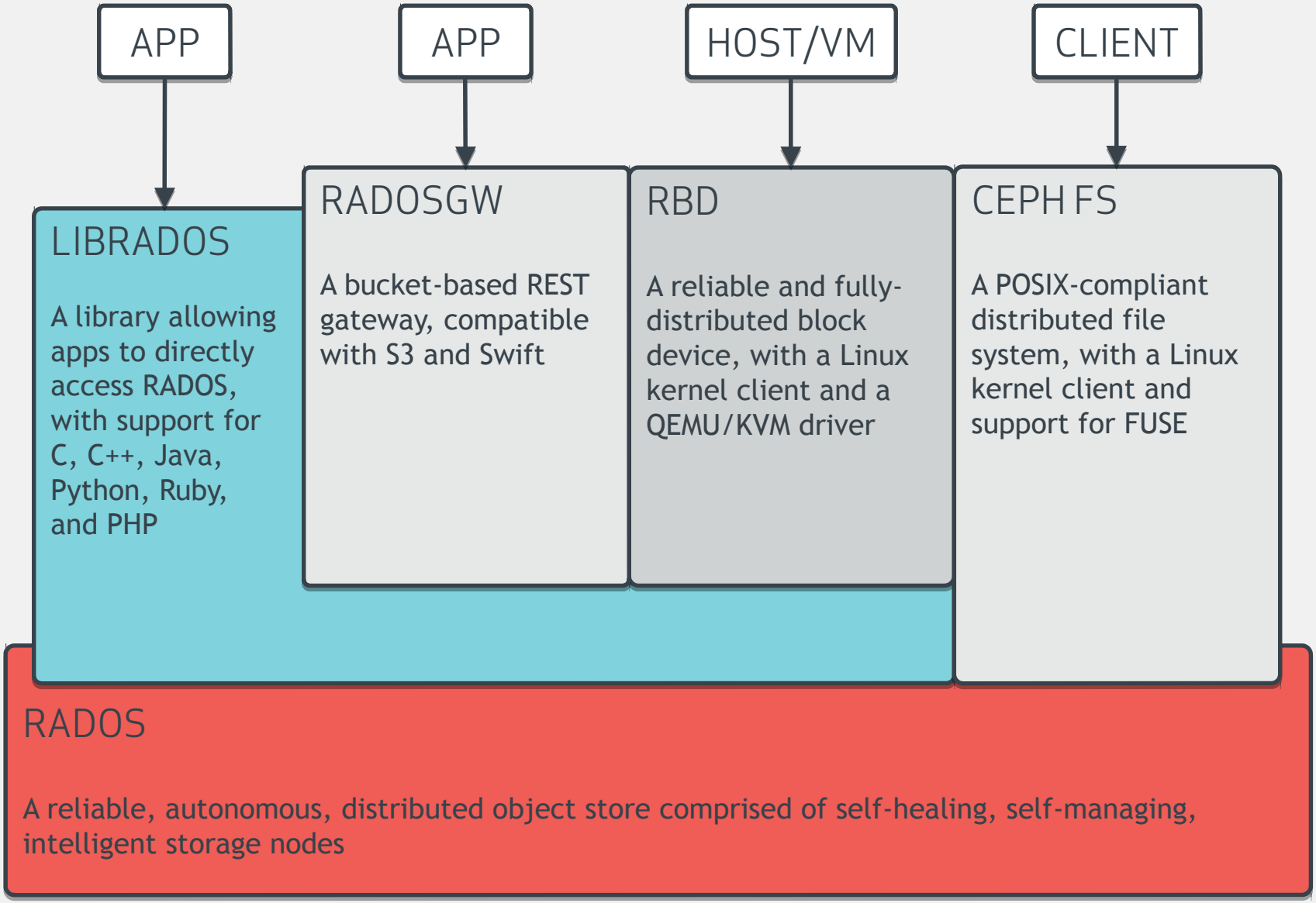


OSDs:

- 10s to 10000s in a cluster
- One per disk
  - (or one per SSD, RAID group…)
- Serve stored objects to clients
- Intelligently peer to perform replication and recovery tasks


Monitors:

- Maintain cluster membership and state
- Provide consensus for distributed decision-making
- Small, odd number
- These do **not** serve stored objects to clients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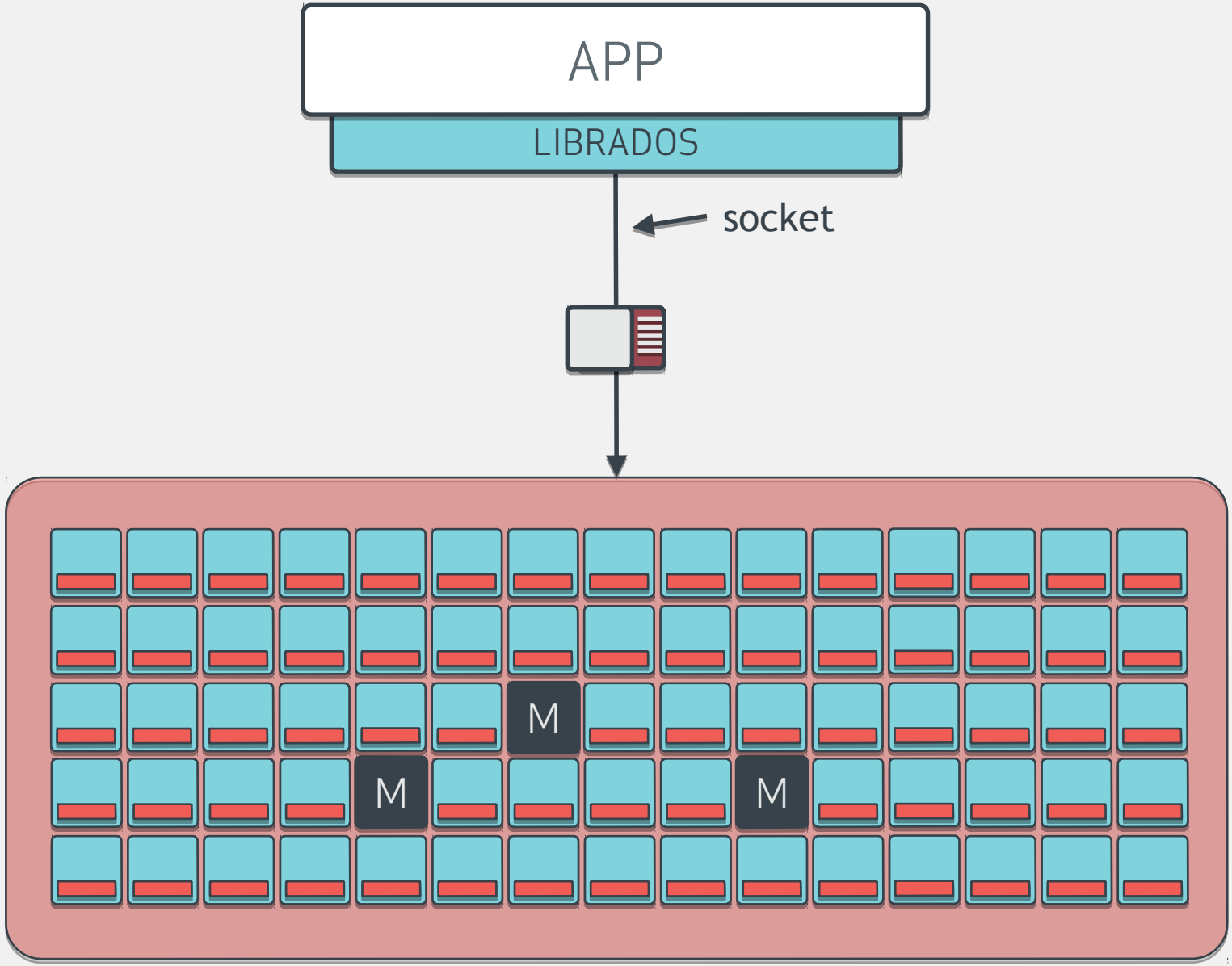
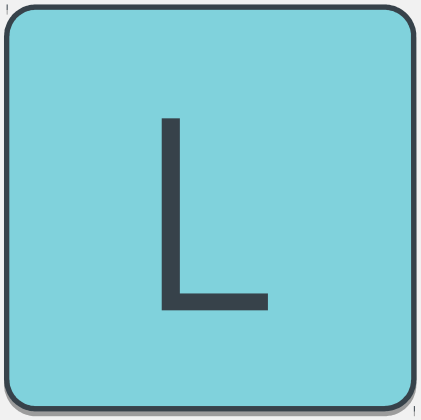
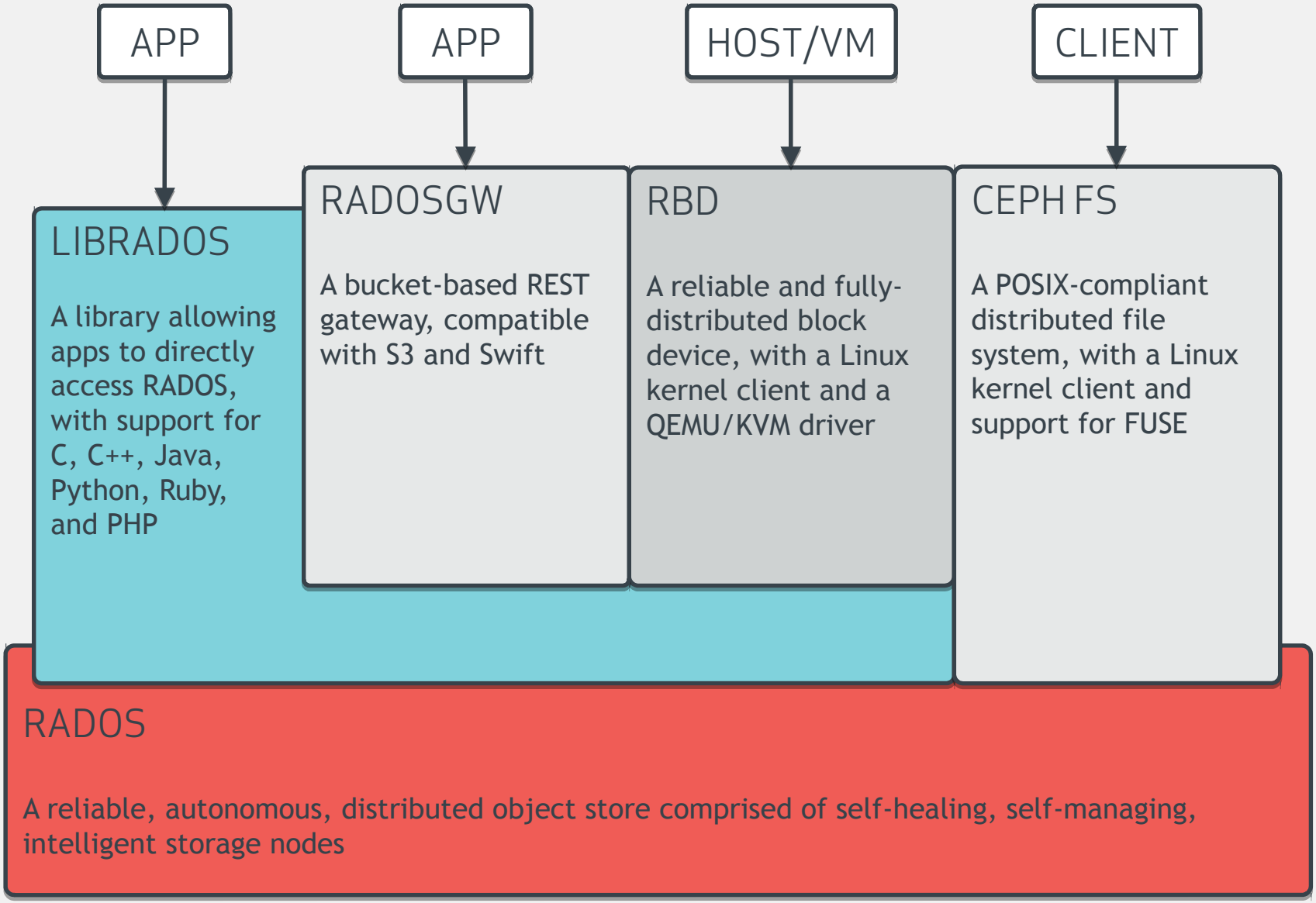

APP
LIBRADOS
socket
M
M
M




LIBRADOS

- Provides direct access to RADOS for applications
- C, C++, Python, PHP, Java, Erlang
- Direct access to storage nodes
- No HTTP overhead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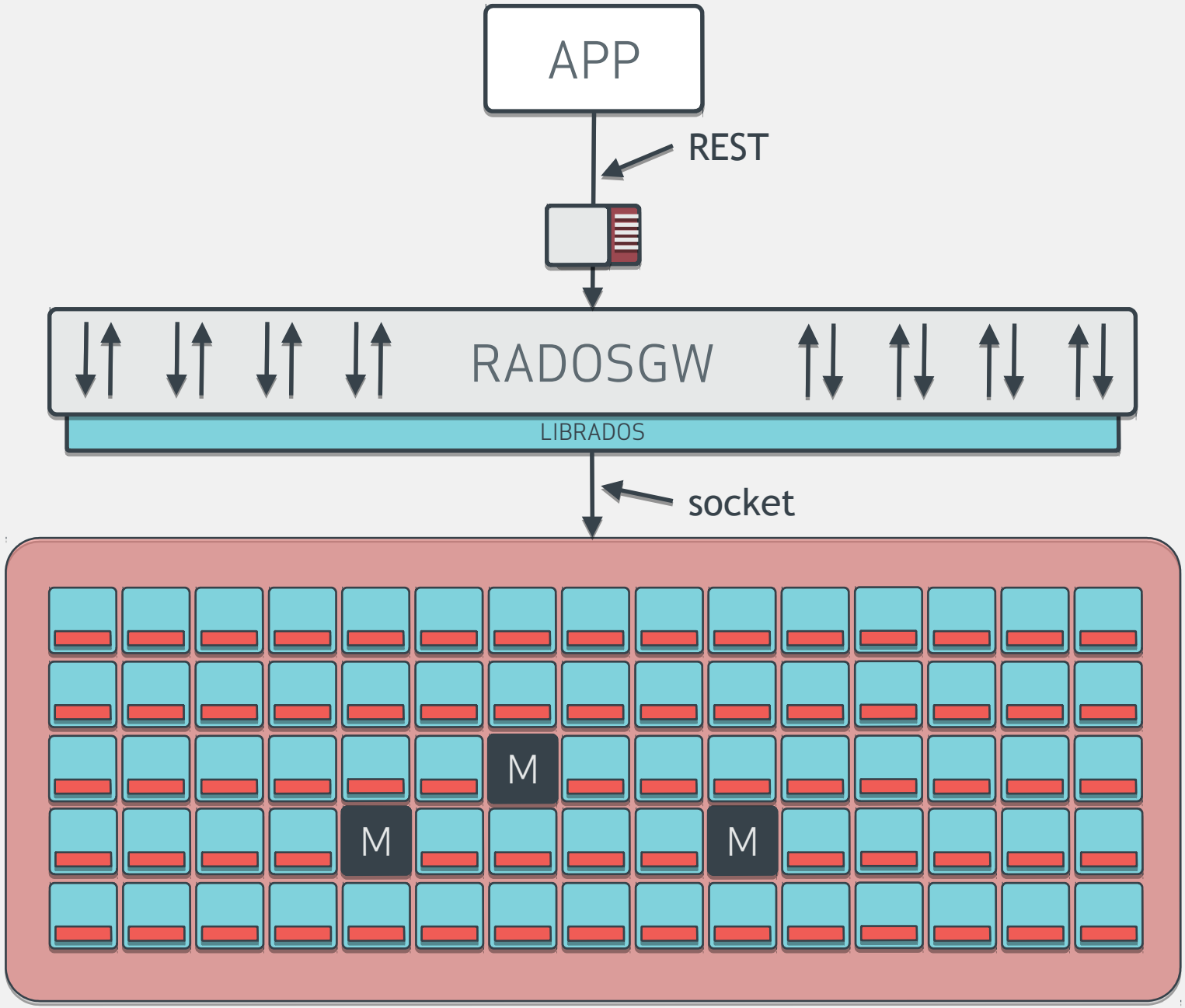
APP
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RADOSGW
LIBRADOS
socket
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M
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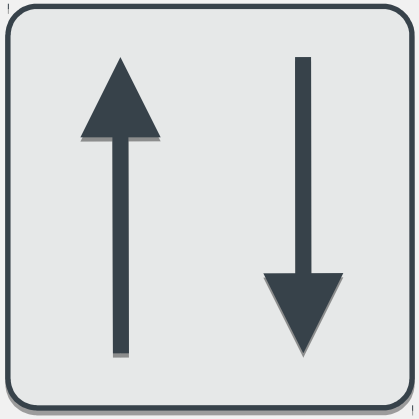
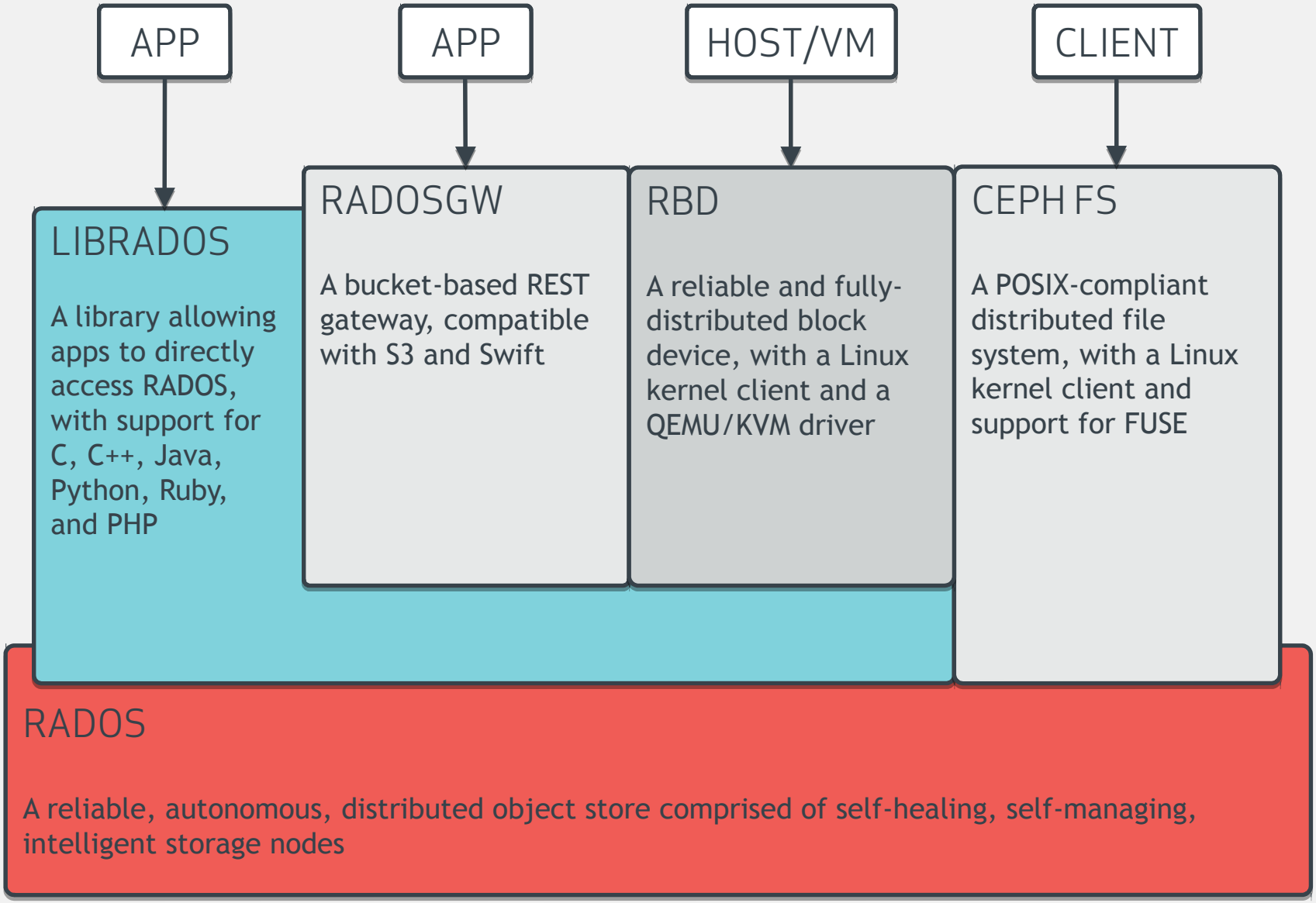


RADOS Gateway:

- REST-based object storage proxy
- Uses RADOS to store objects
- API supports buckets, accounts
- Usage accounting for billing
- Compatible with S3 and Swift applications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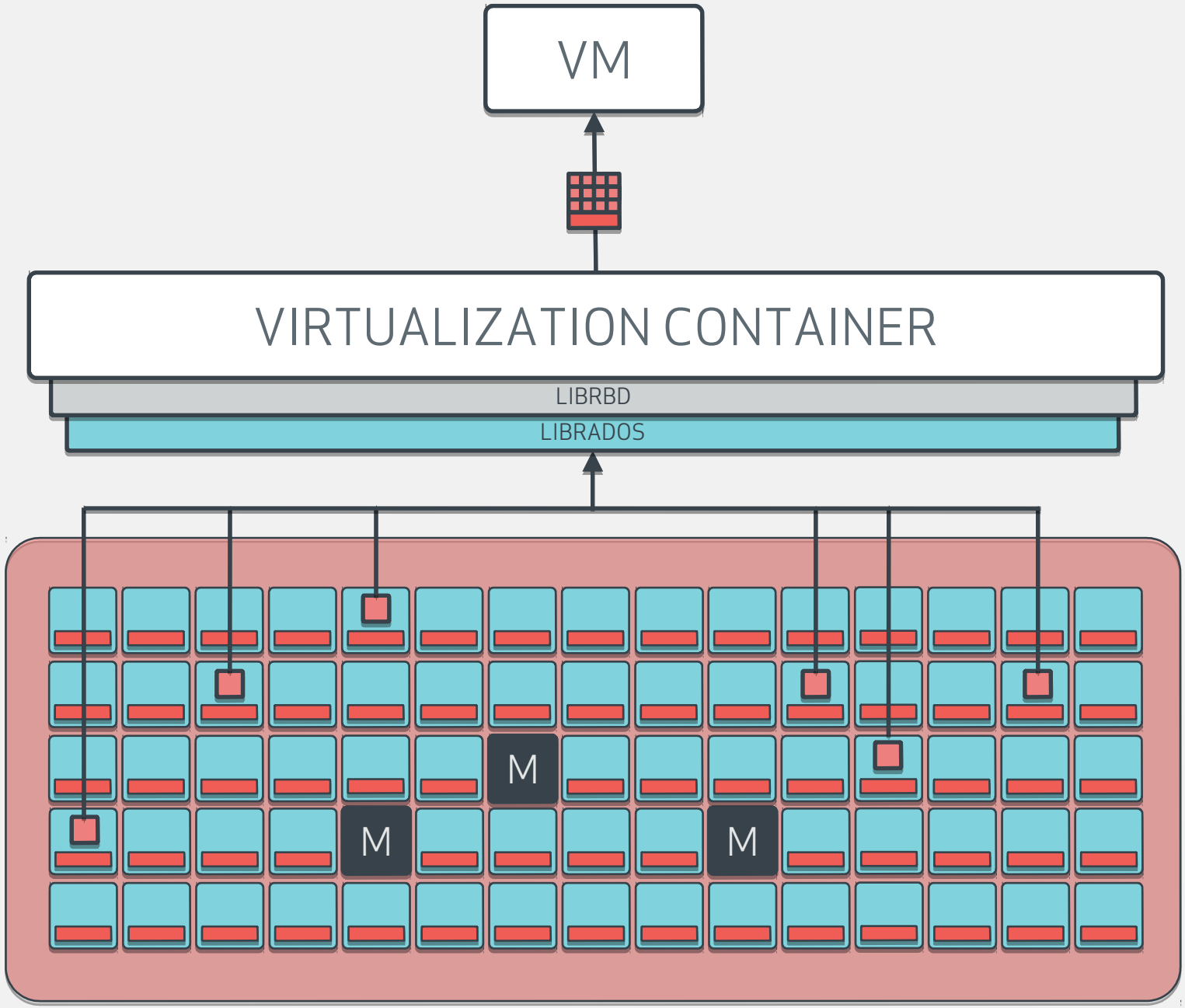
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VIRTUALIZATION CONTAINER
LIBRBD
LIBRADOS
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M
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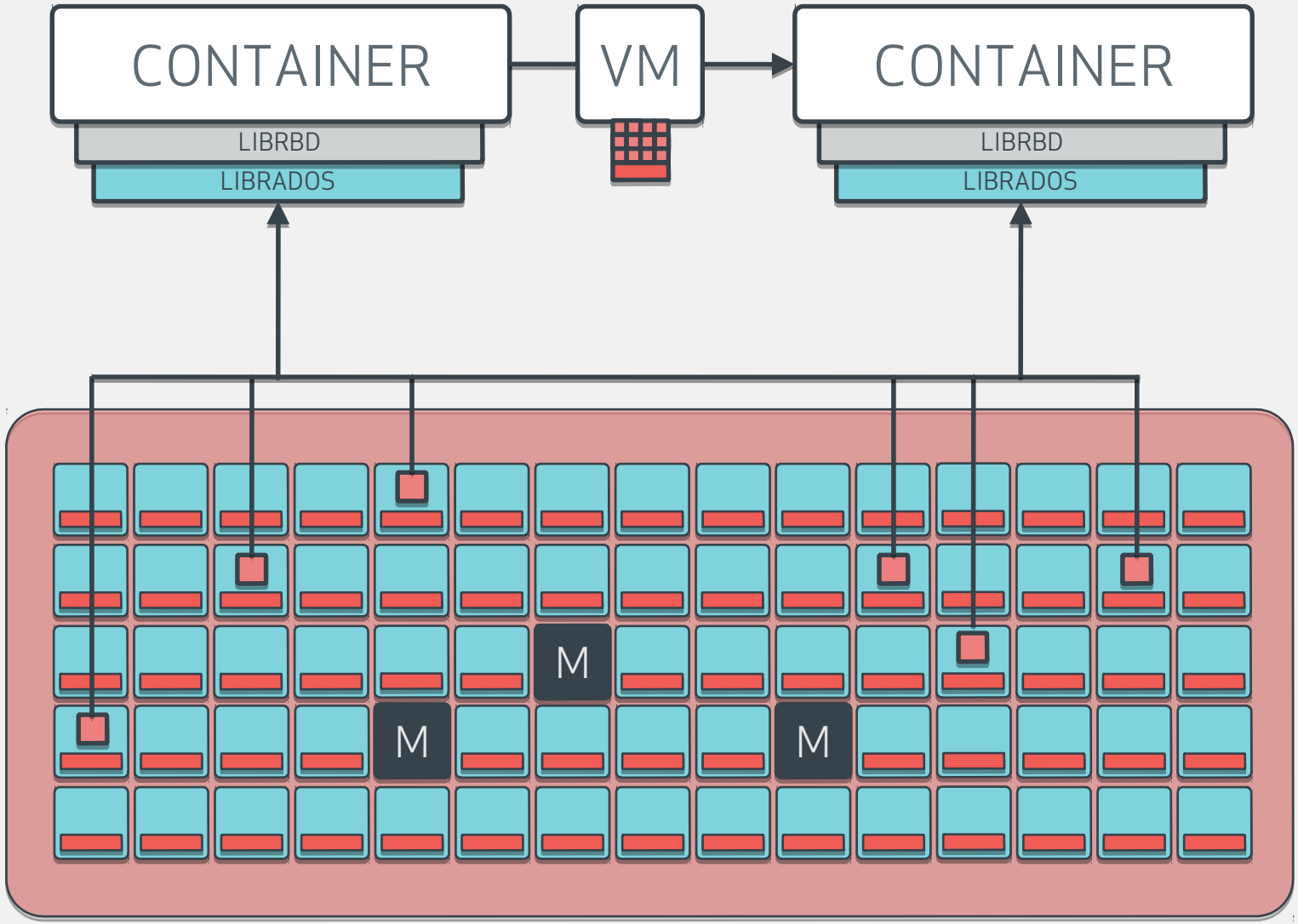
CONTAINER
LIBRBD
LIBRADOS
VM
CONTAINER
LIBRBD
LIBRADOS
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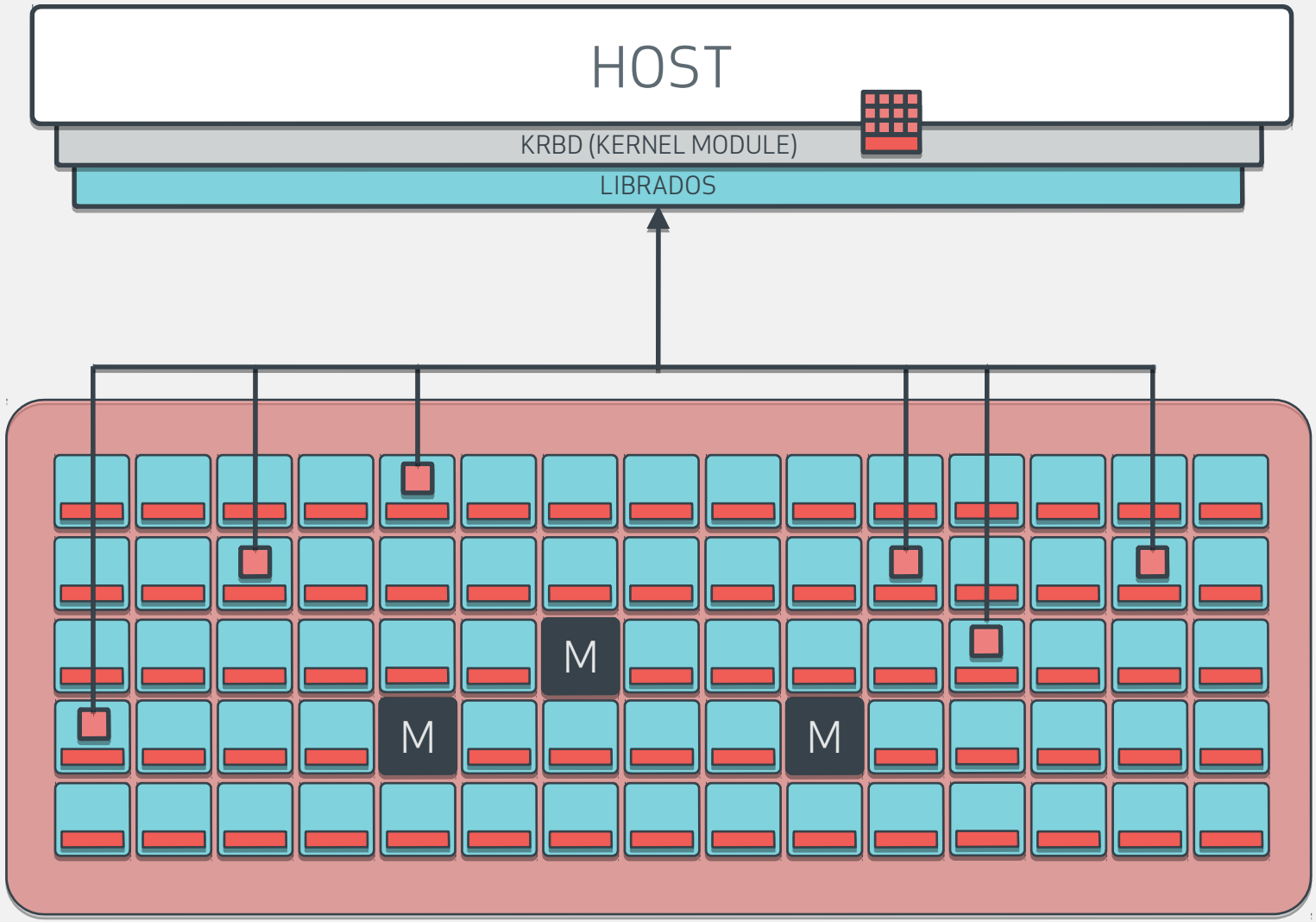
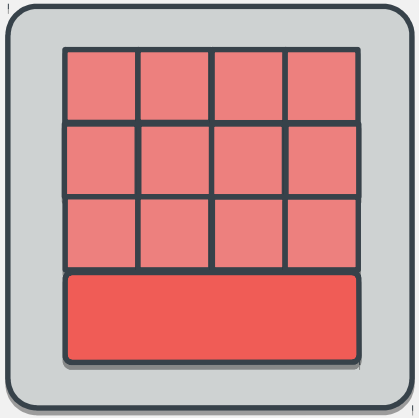
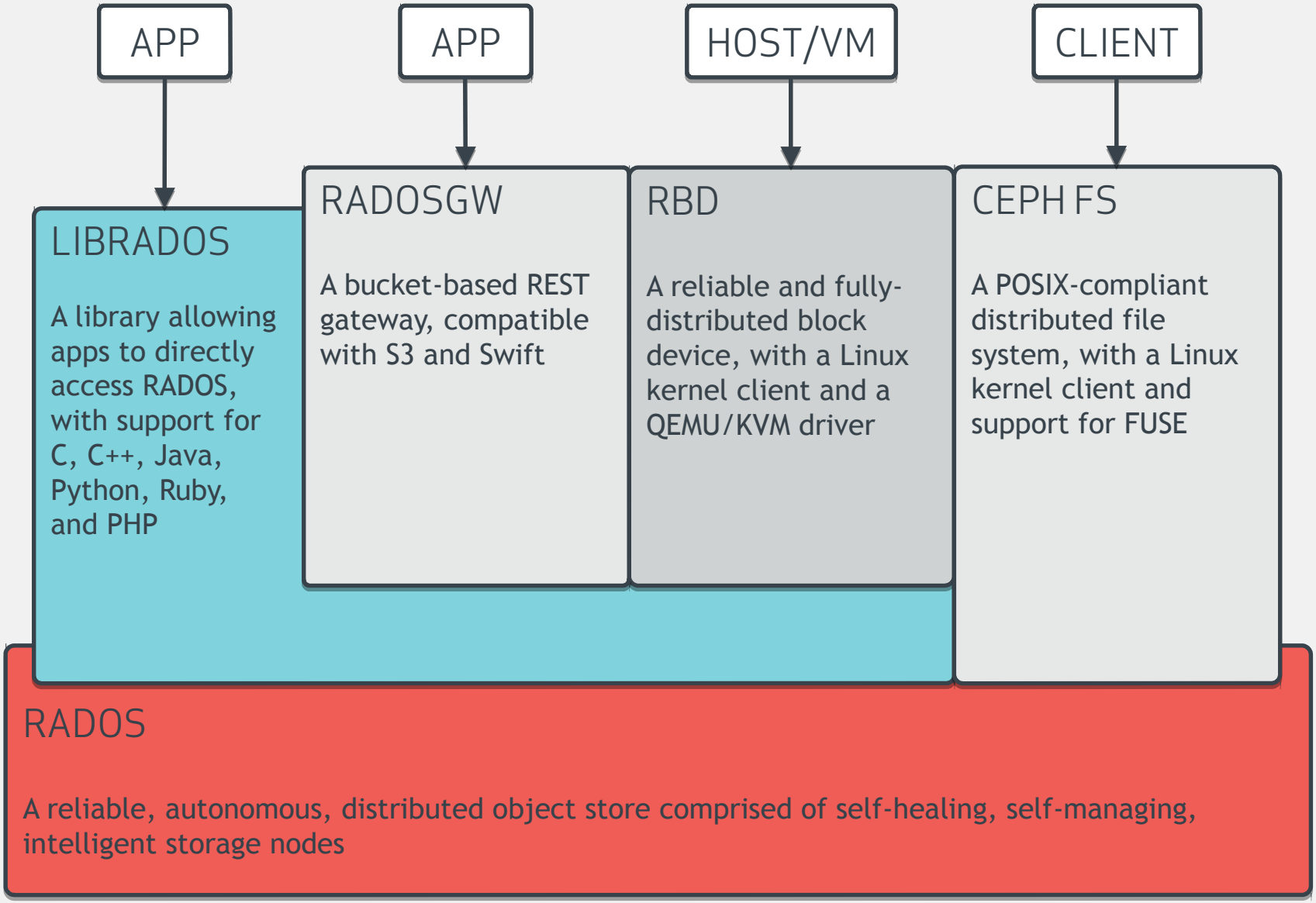

HOST
KRBD (KERNEL MODULE)
LIBRADOS
M
M
M



RADOS Block Device:

- Storage of disk images in RADOS
- Decouples VMs from host
- Images are striped across the cluster (pool)
- Snapshots
- Copy-on-write clones
- Support in:
  - Mainline Linux Kernel (2.6.39+)
  - Qemu/KVM
  - OpenStack, CloudStack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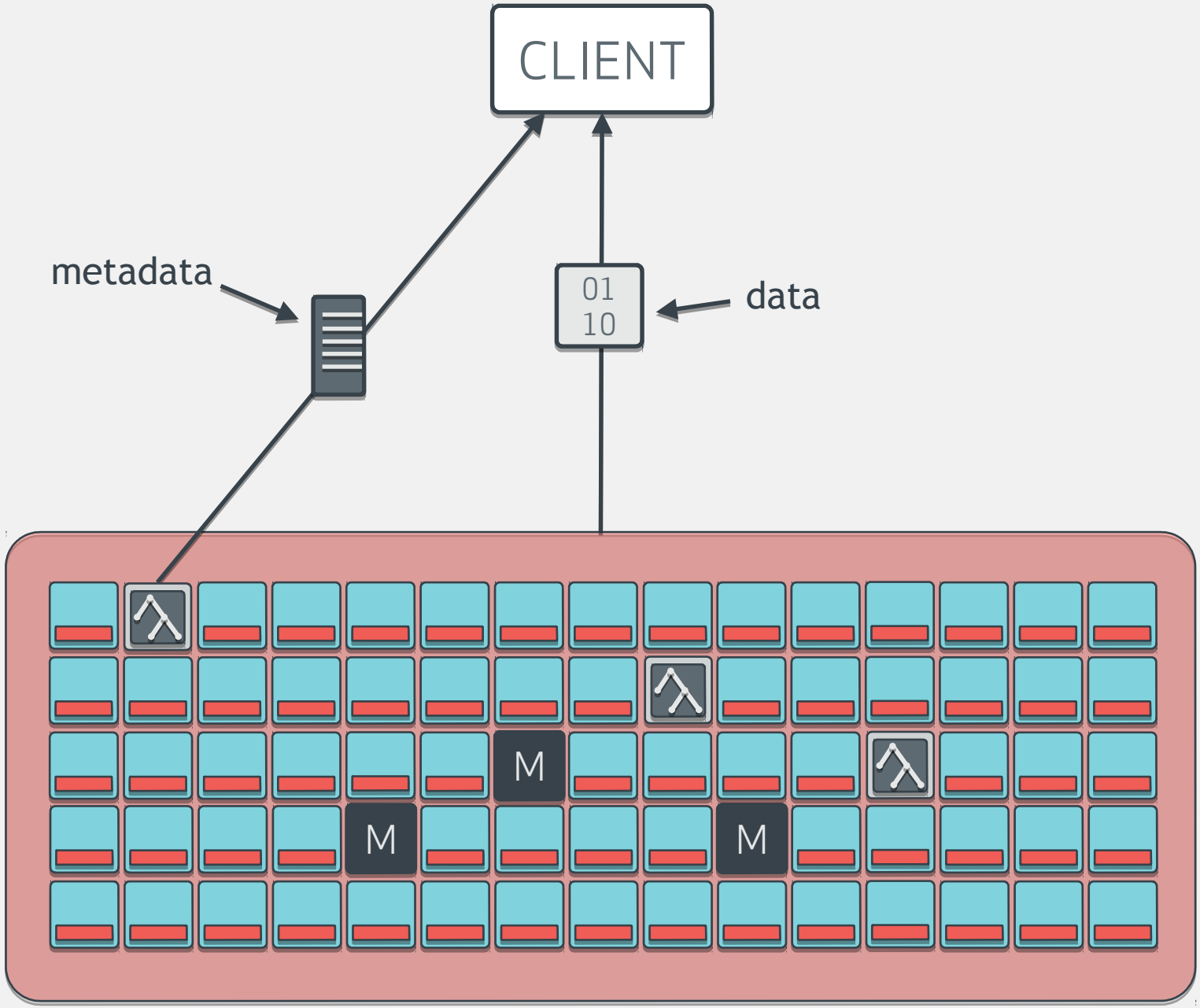
CLIENT
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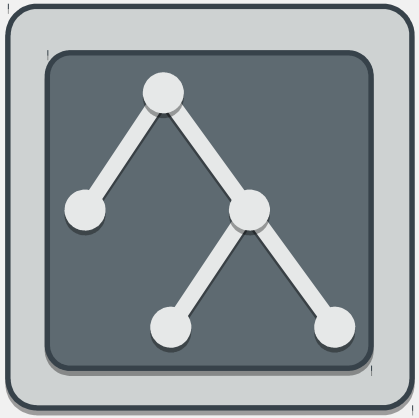
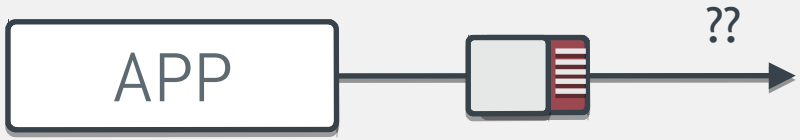


## Metadata Server

- Manages metadata for a POSIX-compliant shared filesystem
  - Directory hierarchy
  - File metadata (owner, timestamps, mode, etc.)
- Stores metadata in RADOS
- Does not serve file data to clients
- Only required for shared filesystem

# What Makes Ceph Unique?

Part one: CRUSH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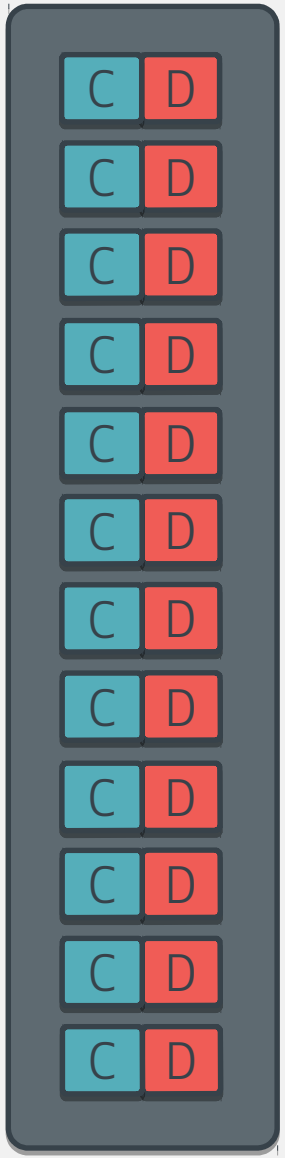
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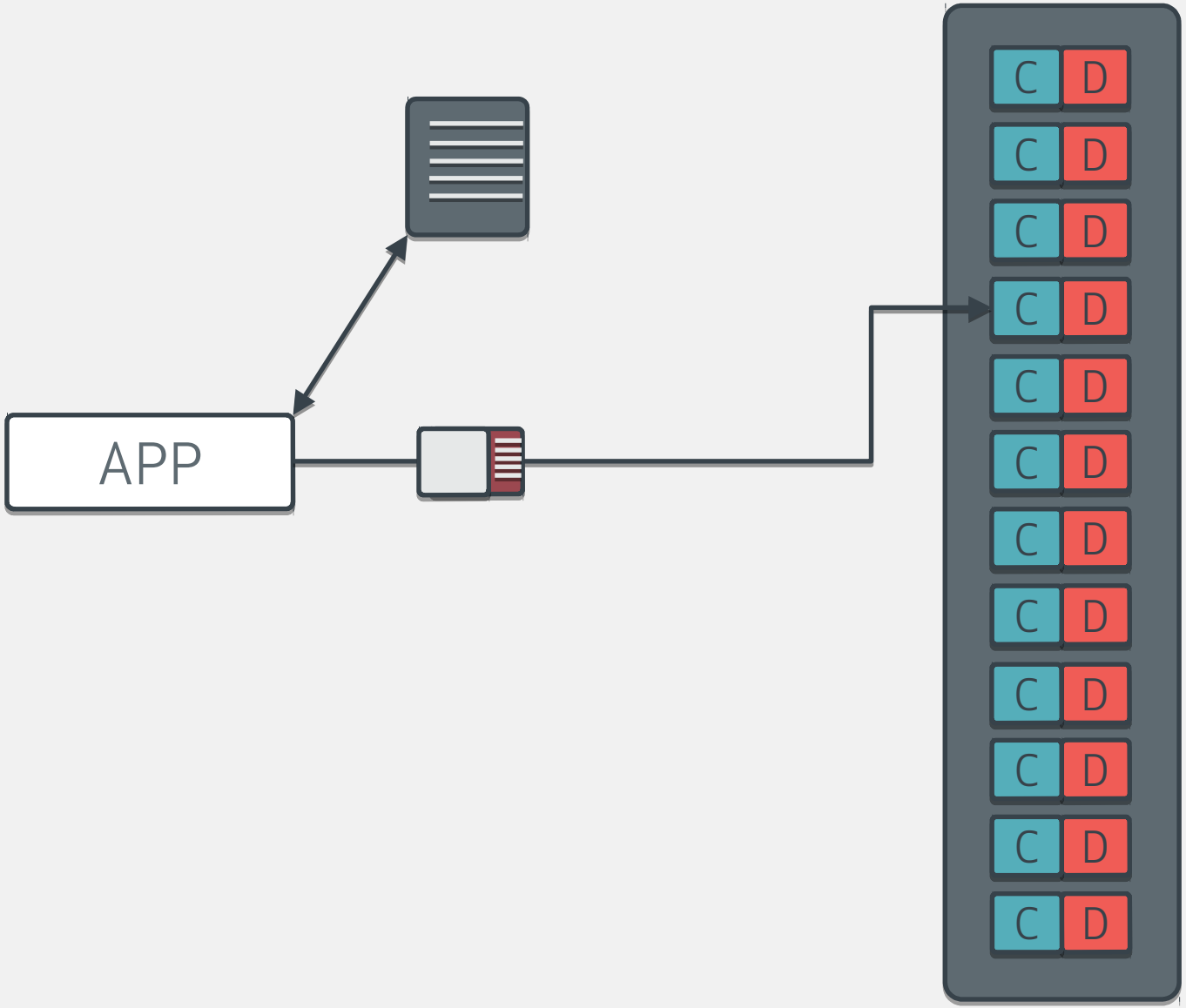
## How Long Did It Take You To Find Your Keys This Morning?

azmeen, Flickr / CC BY 2.0


APP
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D

Dec. 25. To day is certainly a very disagreeable Sunday but for a wonder I have not had the almost everlasting blues which are the legitimate offspring of a troubled mind. It is very evident to my mind that a wrong-thinker or a wrong-doer can not possibly be happy when he persistently keeps a stiffened neck unwilling to bow its head & receive the easy yoke of Christ. Man may, out of the perverseness of his heart, refuse the perusal of Gods written revelation & thus endeavor to screen his faults from the reproaches of conscience, but he can never ignore the revelation of Nature which is an ever open book speaking in softness its is true but notwithstanding irresistible of the Laws of God, the Great Jehovah! to whom be Glory, praise, dominion & power, forever & forever. Amen.

[illegible]

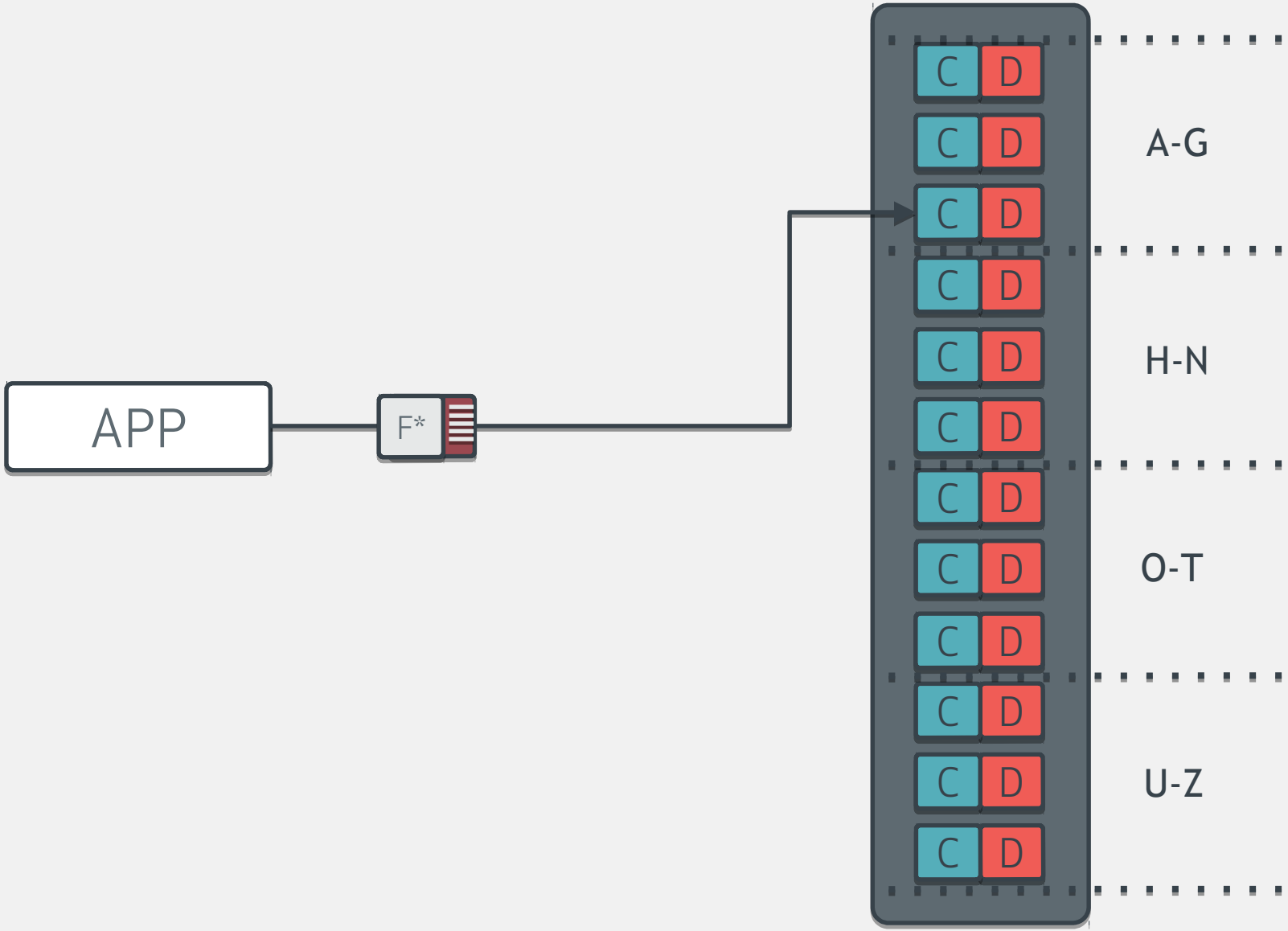
Jan. 2nd. The New Year of 1870. And the Old Year is done at last- gone with all its hopes & fears- gone with all its happiness & sorrow. So be it! We, poor mortals, are rapidly drifting adown the stream of life & strange to say almost entirely unconscious of the remarkable fact. May a Guardian, ever wise & kind Continue with us this year & protect us as He did in the one that has just passed forever into the bosom of Eternity.

May 31st. To day I am to apply for admission to the Bar. It is of course a very important Epoch in my life. It is not without fear that I contemplate my coming examination & without distrust- great distrust - of my untried ability that I shall enter into & upon the arduous duties of the Legal Profession but with an unbounded trust in the kindness & perfection of my Great Creator & that He delights to take care of the creatures of his Infinite Wisdom. Grant Heavenly Father, through the Intercession of Christ our Savior & Intercessor that my career may be honorable & just; that I may espouse the side of Justice, & may never be found in the ranks of Oppression & Injustice; that the weak, the helpless, the poor, may ever find in me a warm, sympathizing friend & an able & zealous and successful advocate; May all the ends I aimest at, be my Gods, my countrys & Truths."

W. Veirs Bouic, Jr.

Montgomery County, Maryland

July 8th [illegible]


APP
F*
C
D
A-G
H-N
O-T
U-Z

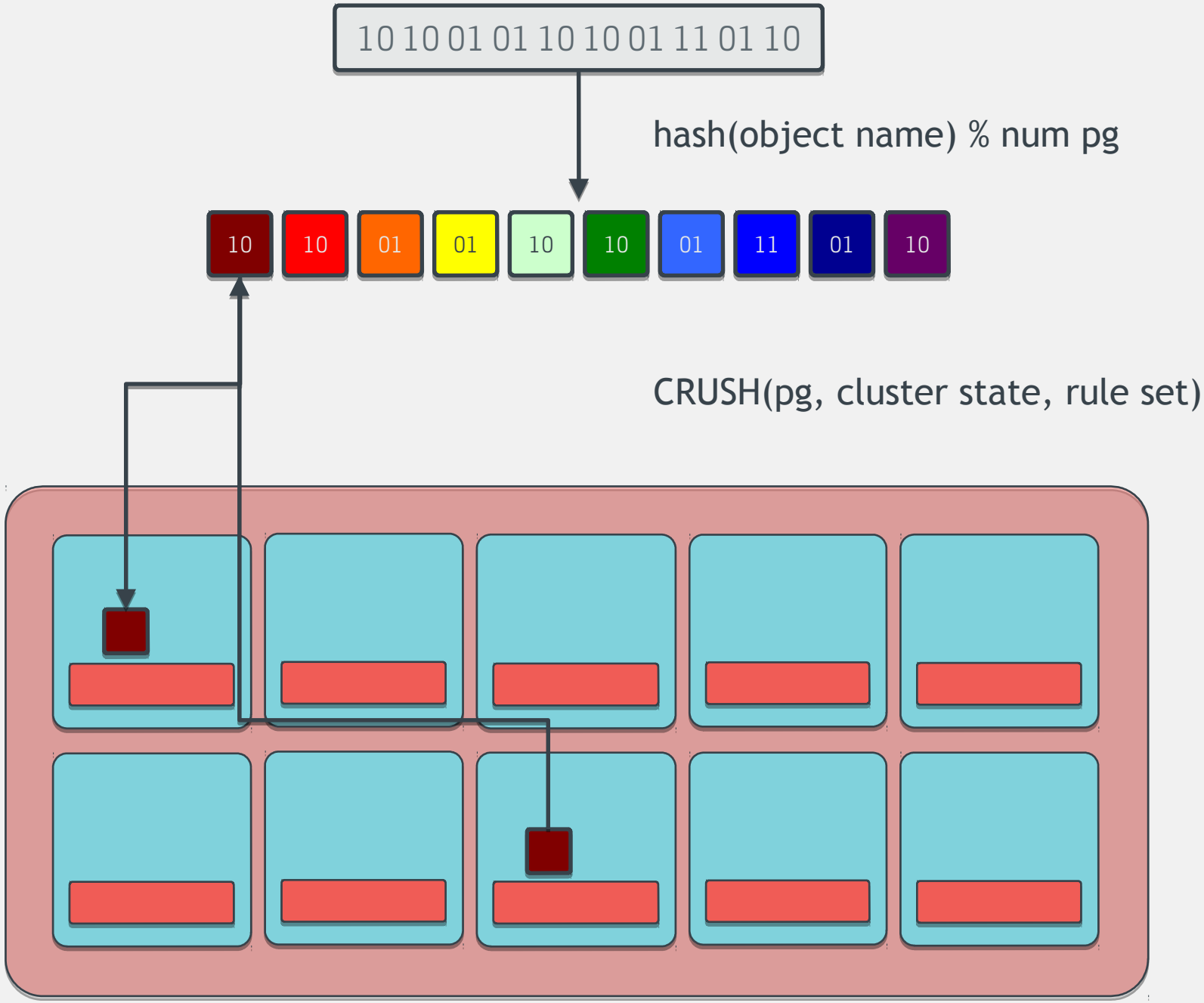

# I Always Put My Keys on the Hook By the Door

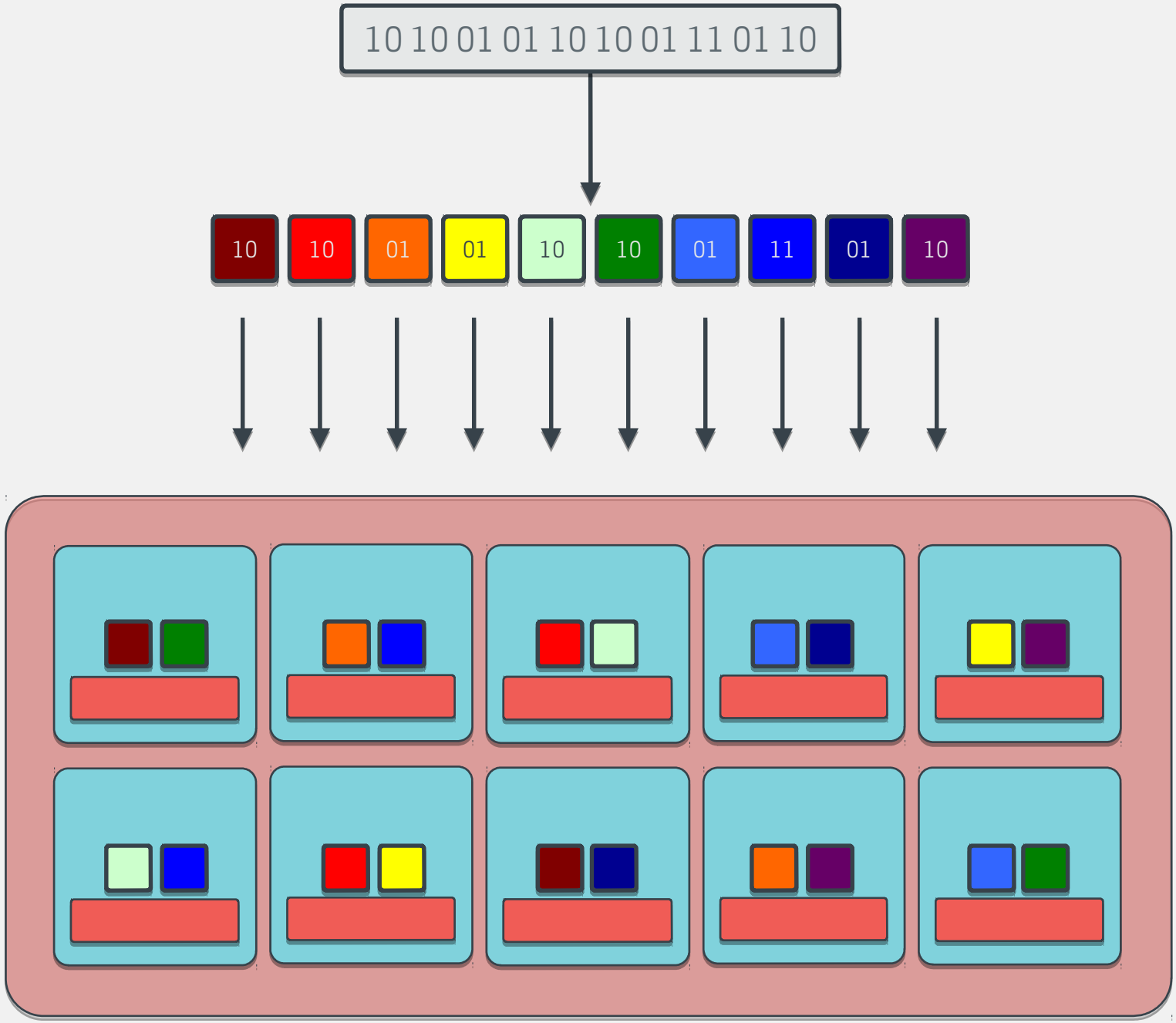
vitamindave, Flickr / CC BY 2.0

HOW DO YOU
FIND YOUR KEYS
WHEN YOUR HOUSE
IS
INFINITELY BIG
AND
ALWAYS CHANGING?

## The Answer: CRUSH!!!!!

pasukaru76, Flickr / CC SA 2.0


10 10 01 01 10 10 01 11 01 10
hash(object name) % num pg
10
10
01
01
10
10
01
11
01
10
CRUSH(pg, cluster state, rule set)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10
10
01
01
10
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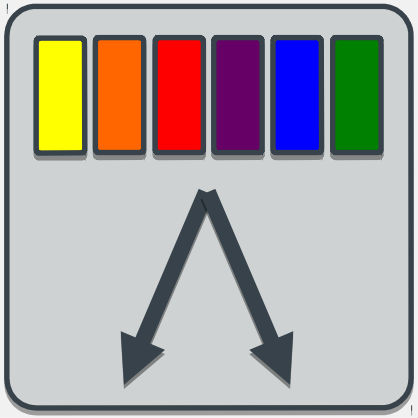
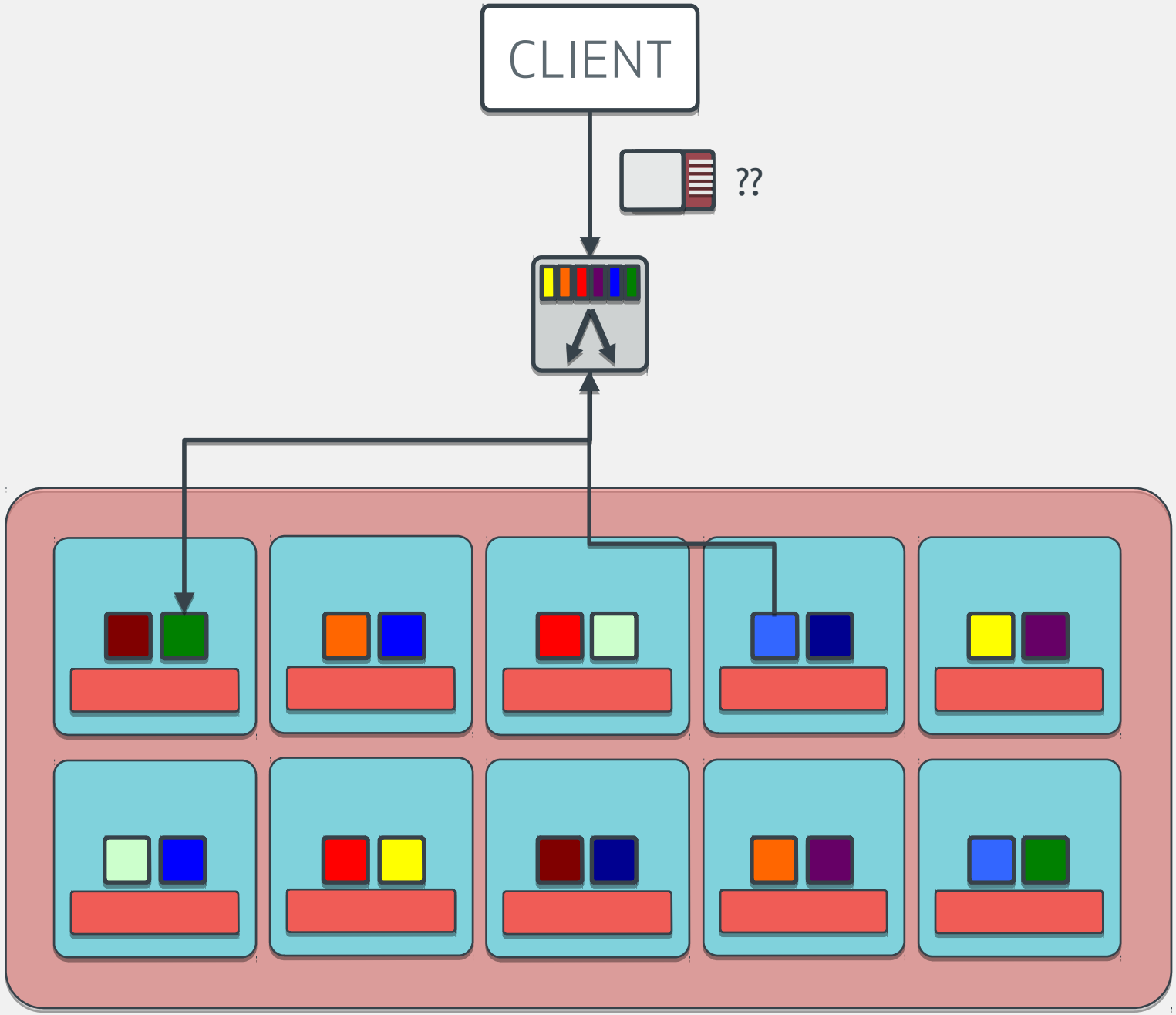
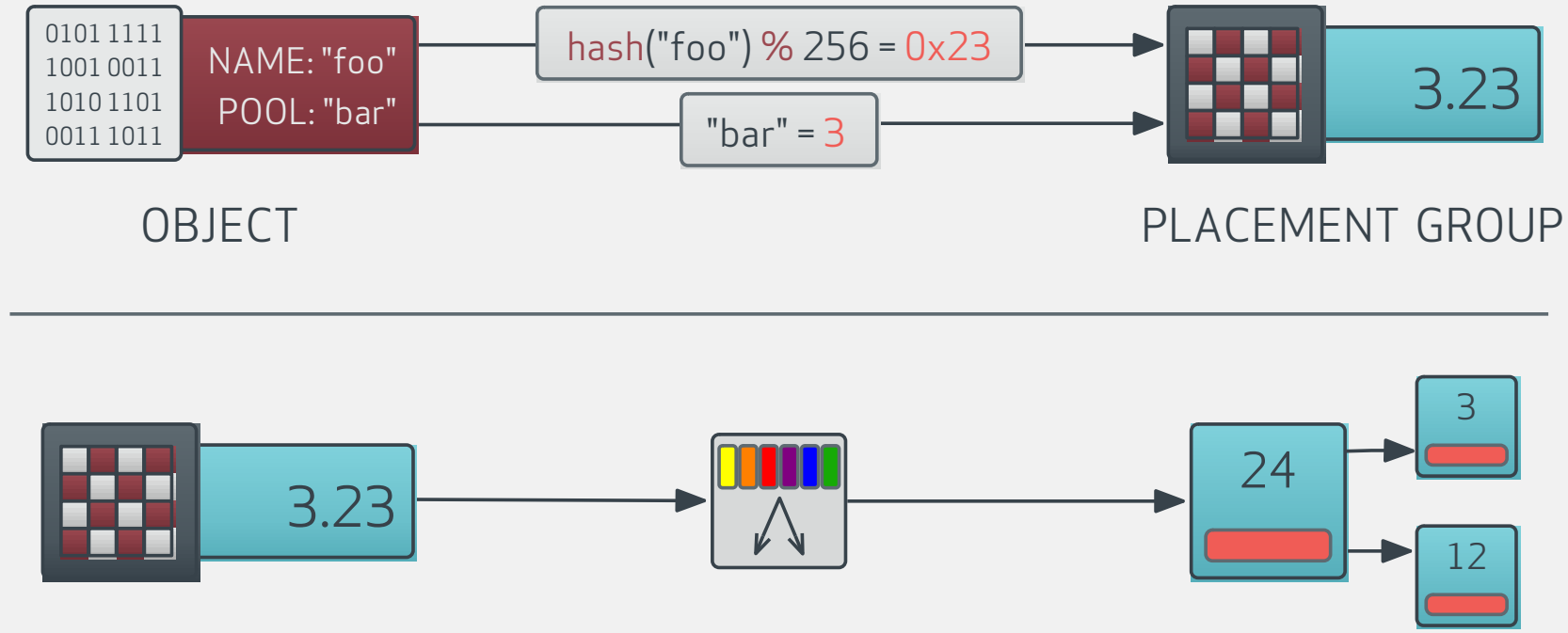
01
11
01
10

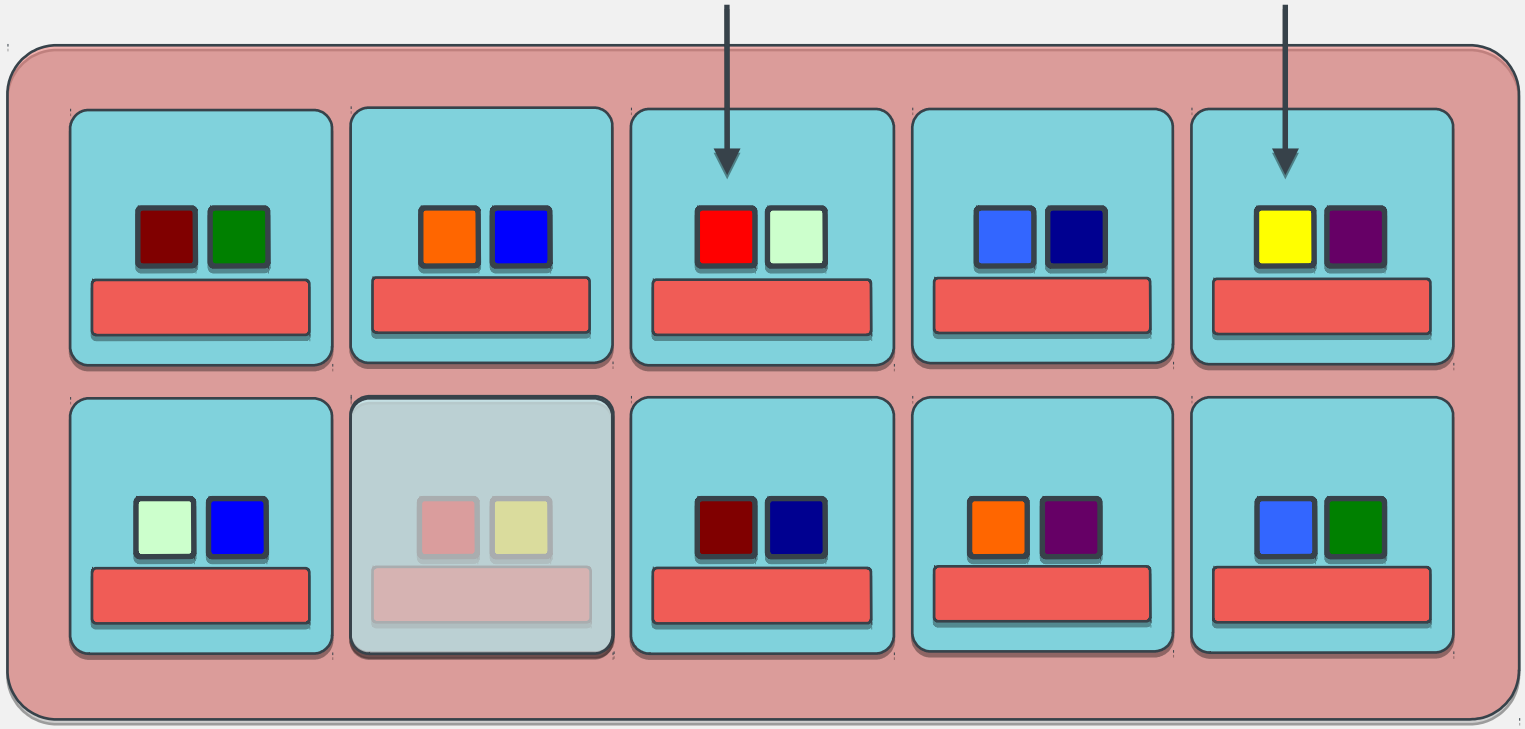


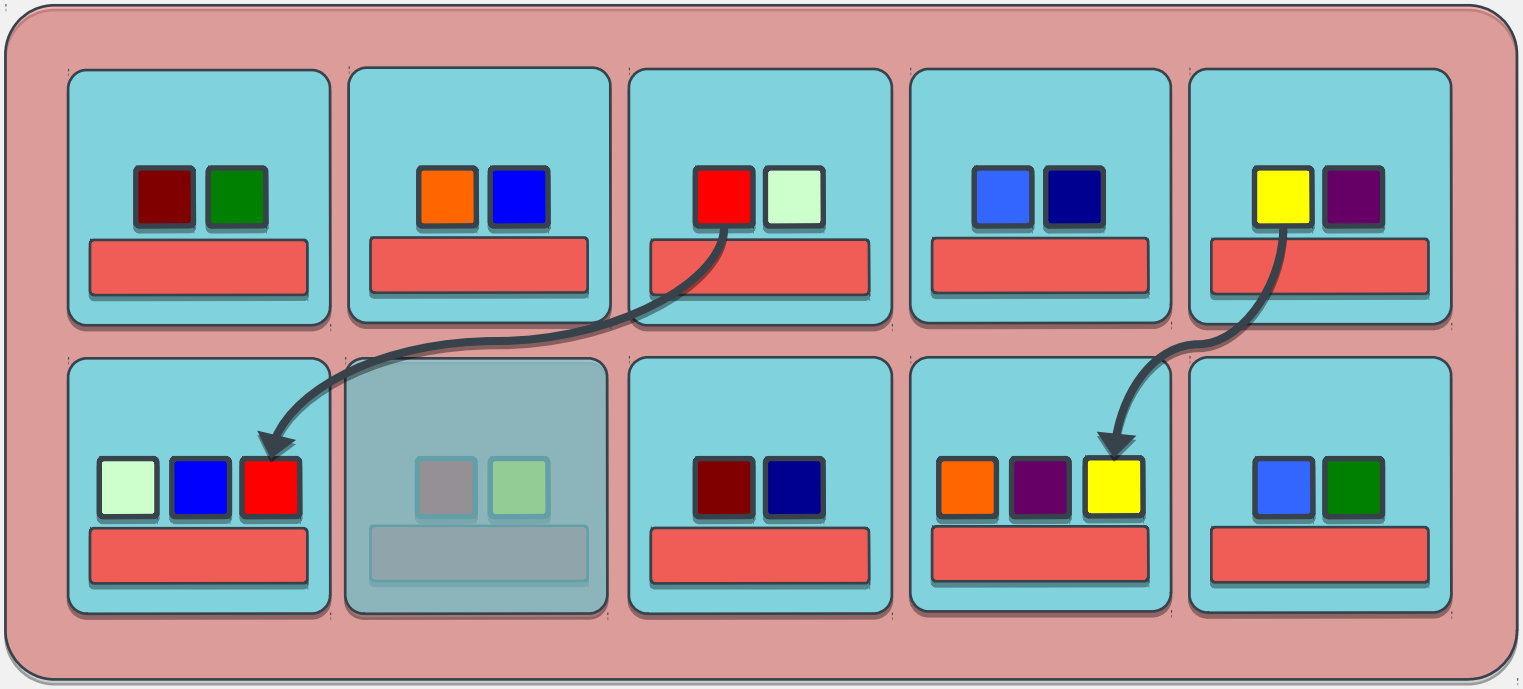
CRUSH

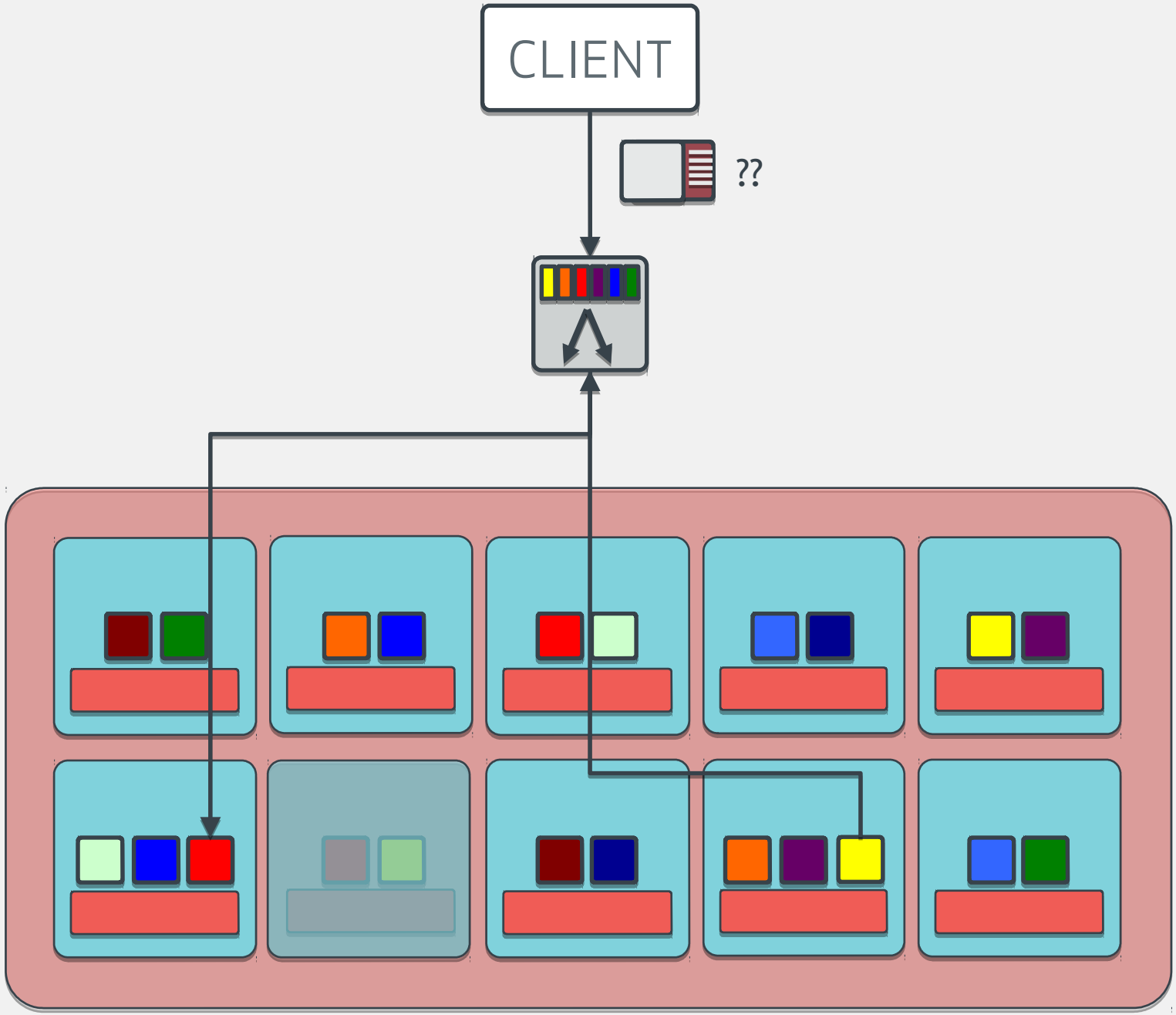
- Pseudo-random placement algorithm
  - Fast calculation, **no lookup**
  - Repeatable, deterministic
- Statistically uniform distribution
- Stable mapping
  - Limited data migration on change
- Rule-based configuration
  - Infrastructure topology aware
  - Adjustable replication
  - Weighting


CLIENT
??


0101 1111
1001 0011
1010 1101
0011 1011
NAME: "foo"
POOL: "bar"
hash("foo") % 256 = 0x23
"bar" = 3
3.23
OBJECT
PLACEMENT GROUP
3.23
24
3
12
PLACEMENT GROUP
CRUSH
TARGET OSDs

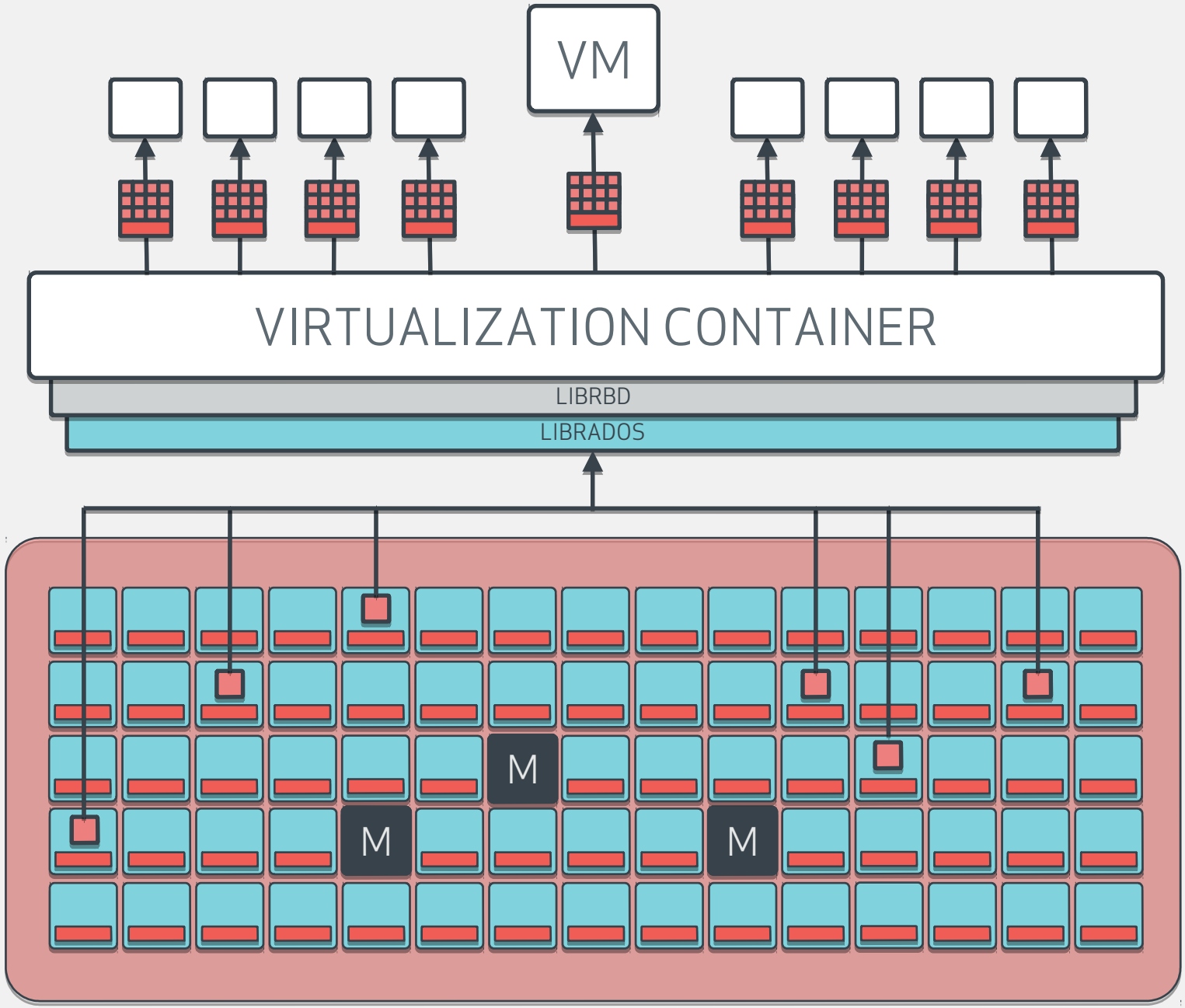




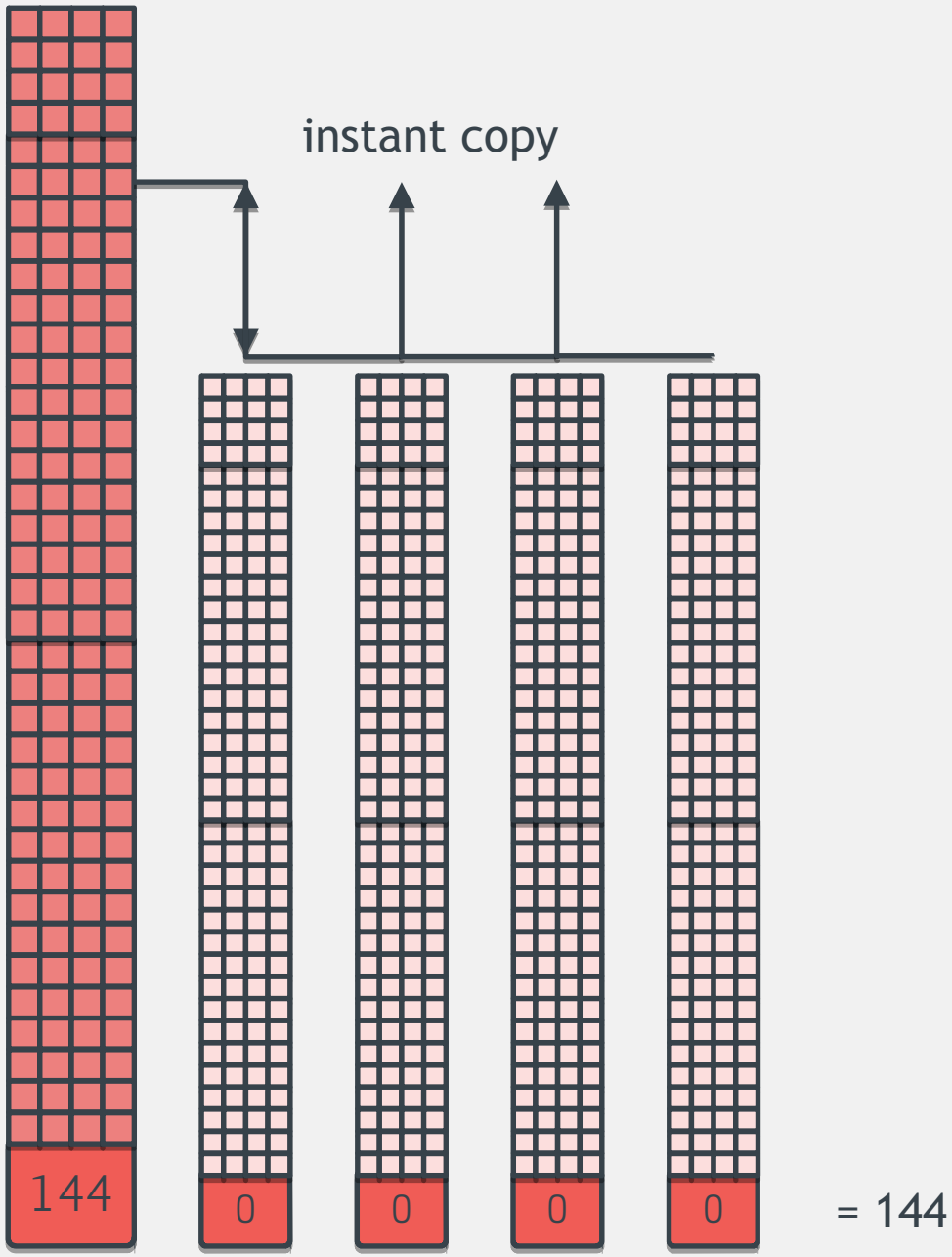

CLIENT
??

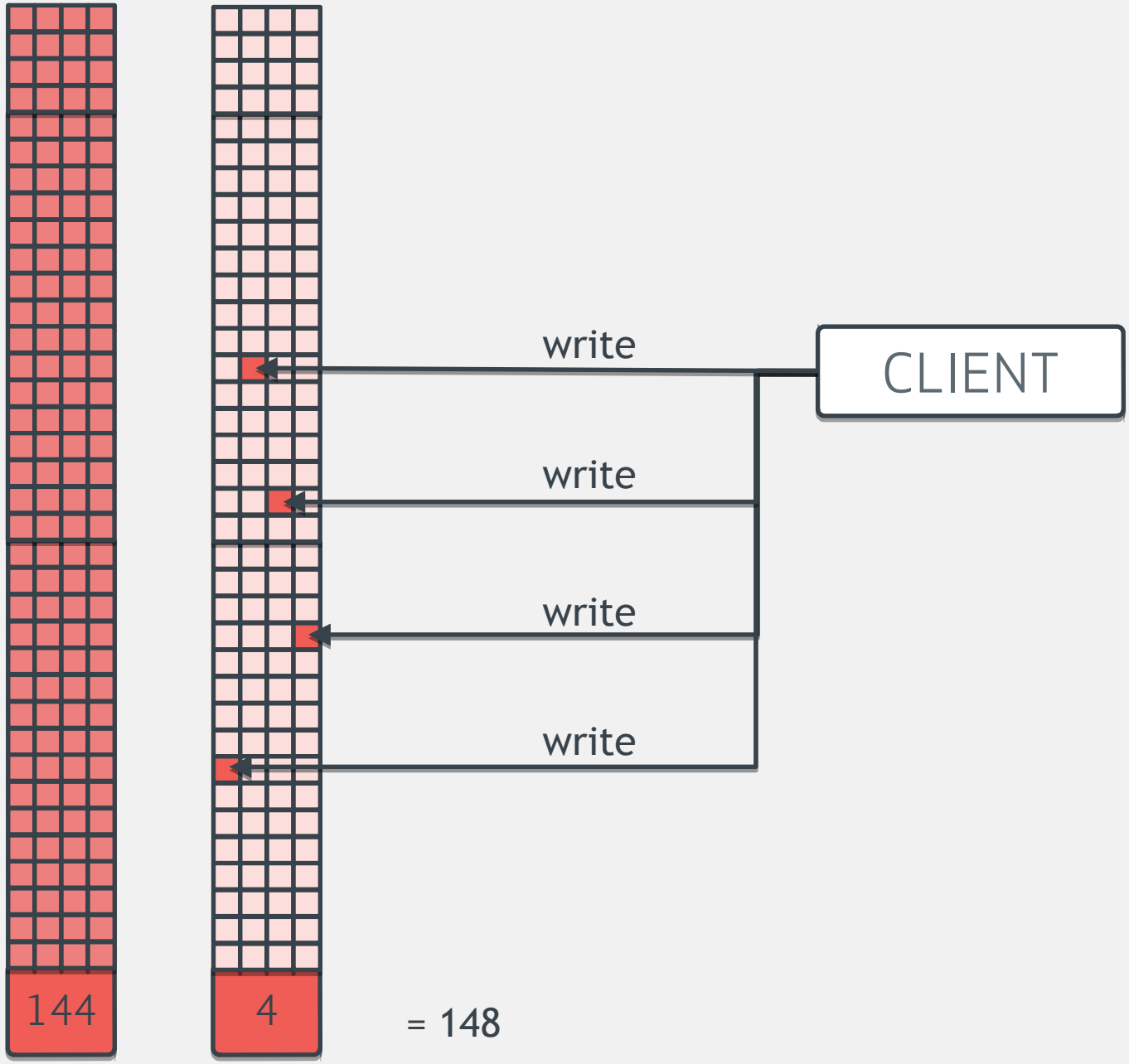
# What Makes Ceph Unique

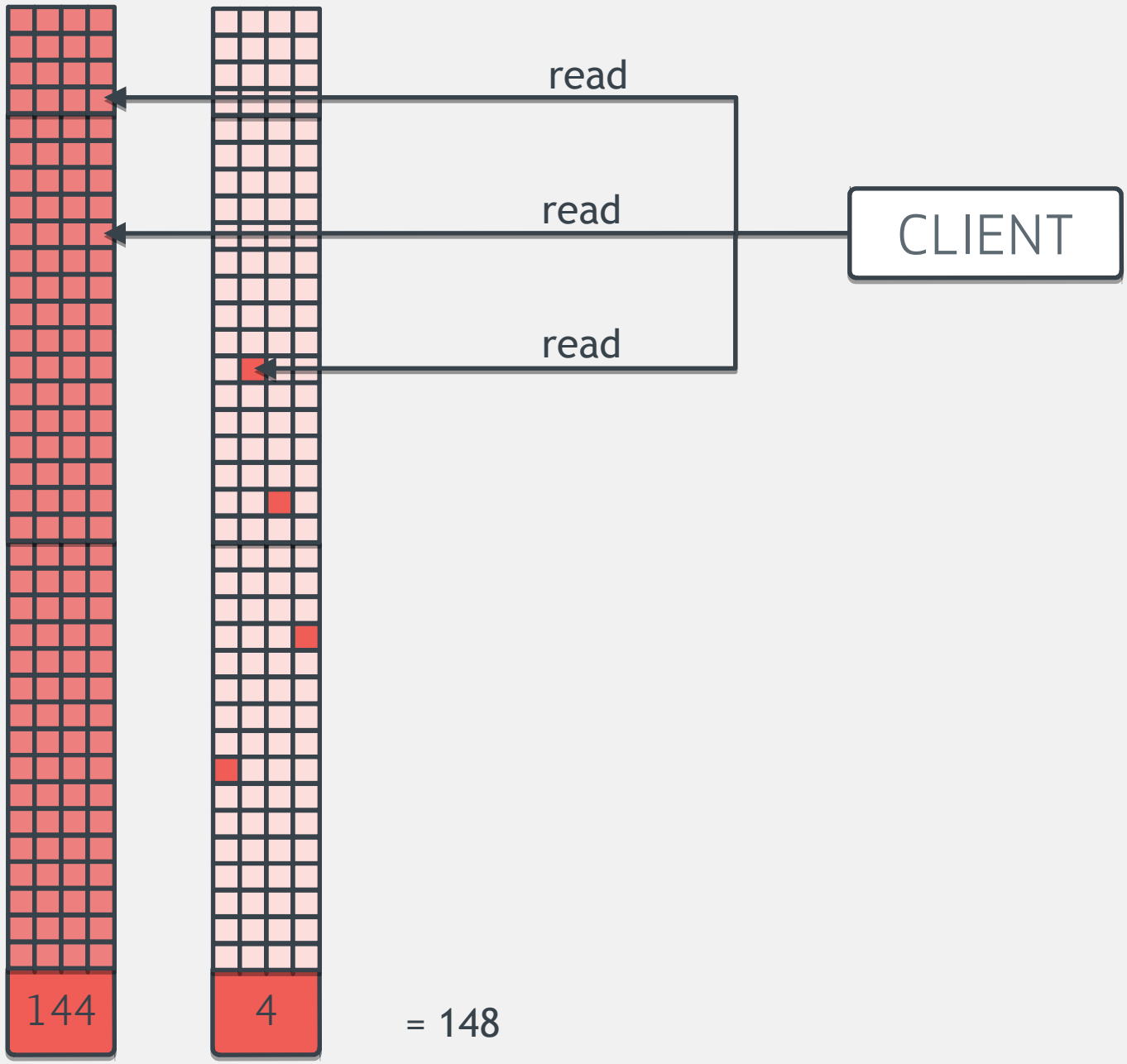
Part two: thin provisioning


VM
VIRTUALIZATION CONTAINER
LIBRBD
LIBRADOS
M
M
M

HOW DO YOU
SPIN UP
THOUSANDS OF VMs
INSTANTLY
AND
EFFICIENTLY?


instant copy
144
0
0
0
0
= 144


write
write
write
write
CLIENT
144
4
= 148


read
read
read
CLIENT
144
4
= 148

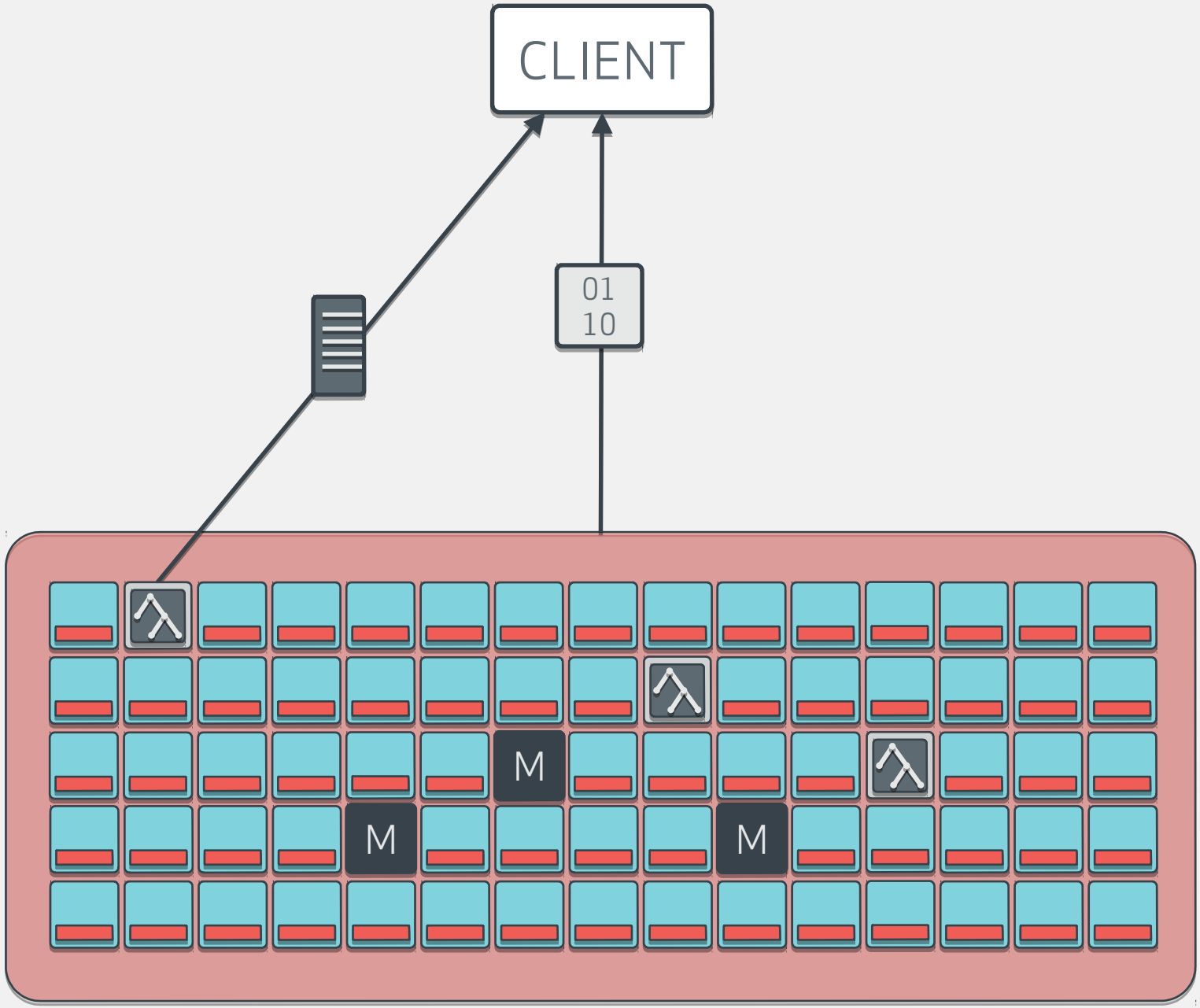
# What Makes Ceph Unique?

Part three: clustered metadata

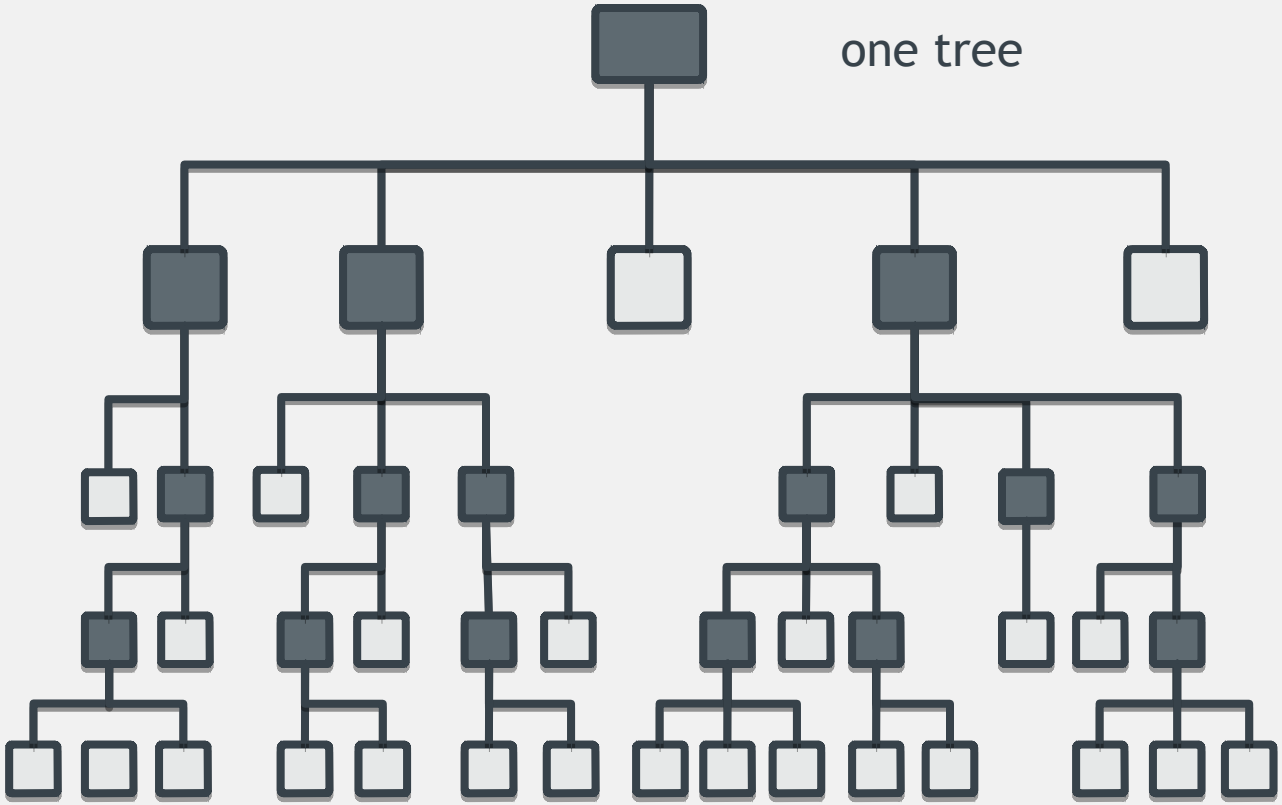
```
lrwxrwxrwx  1 root root       26 Apr 26 17:54 libgssapi_krb5.so -> mit-krb5/libgssapi_krb5.s
lrwxrwxrwx  1 root root       21 Apr 26 17:55 libgssapi_krb5.so.2 -> libgssapi_krb5.so.2.2
-rw-r--r-- 50 root root   216824 Jul 31  2012 libgssapi_krb5.so.2.2
lrwxrwxrwx  1 root root       13 Apr 26 17:54 libgs.so.8 -> libgs.so.8.71
-rw-r--r-- 17 root root  9478048 Jan 25  2011 libgs.so.8.71
lrwxrwxrwx  1 root root       21 Apr 26 17:55 libgssrpc.so -> mit-krb5/libgssrpc.so
lrwxrwxrwx  1 root root       16 Apr 26 17:55 libgssrpc.so.4 -> libgssrpc.so.4.1
-rw-r--r-- 50 root root   115352 Jul 31  2012 libgssrpc.so.4.1
-rw-r--r-- 50 root root    21832 Sep  8  2010 libgthread-2.0.a
-rw-r--r-- 50 root root      972 Sep  8  2010 libgthread-2.0.la
lrwxrwxrwx  1 root root       26 Apr 26 17:55 libgthread-2.0.so -> libgthread-2.0.so.0.2400.
lrwxrwxrwx  1 root root       26 Apr 26 17:55 libgthread-2.0.so.0 -> libgthread-2.0.so.0.240
-rw-r--r-- 50 root root    17704 Sep  8  2010 libgthread-2.0.so.0.2400.2
drwxr-xr-x  2 root root     4096 Apr 26 18:00 libgtk2.0-0
-rw-r--r-- 49 root root  9275282 Oct 14  2010 libgtk-x11-2.0.a
-rw-r--r-- 49 root root      981 Oct 14  2010 libgtk-x11-2.0.la
lrwxrwxrwx  1 root root       26 Apr 26 17:55 libgtk-x11-2.0.so -> libgtk-x11-2.0.so.0.2000.
lrwxrwxrwx  1 root root       26 Apr 26 17:55 libgtk-x11-2.0.so.0 -> libgtk-x11-2.0.so.0.200
-rw-r--r-- 49 root root  4319784 Oct 14  2010 libgtk-x11-2.0.so.0.2000.1
lrwxrwxrwx  1 root root       15 Apr 26 17:55 libgvc.so -> libgvc.so.5.0.0
lrwxrwxrwx  1 root root       15 Apr 26 17:55 libgvc.so.5 -> libgvc.so.5.0.0
-rw-r--r-- 49 root root   504424 Jul  5  2010 libgvc.so.5.0.0
lrwxrwxrwx  1 root root       16 Apr 26 17:55 libgvpr.so -> libgvpr.so.1.0.0
lrwxrwxrwx  1 root root       16 Apr 26 17:55 libgvpr.so.1 -> libgvpr.so.1.0.0
-rw-r--r-- 50 root root   482856 Jul  5  2010 libgvpr.so.1.0.0
-rw-r--r-- 50 root root   267948 Apr 13  2009 libHalf.a
lrwxrwxrwx  1 root root       16 Apr 26 17:55 libHalf.so -> libHalf.so.6.0.0
lrwxrwxrwx  1 root root       16 Apr 26 17:55 libHalf.so.6 -> libHalf.so.6.0.0
-rw-r--r-- 50 root root   269992 Apr 13  2009 libHalf.so.6.0.0
-rw-r--r-- 50 root root    52850 Nov  1  2009 libhistory.a
```

# POSIX Filesystem Metadata

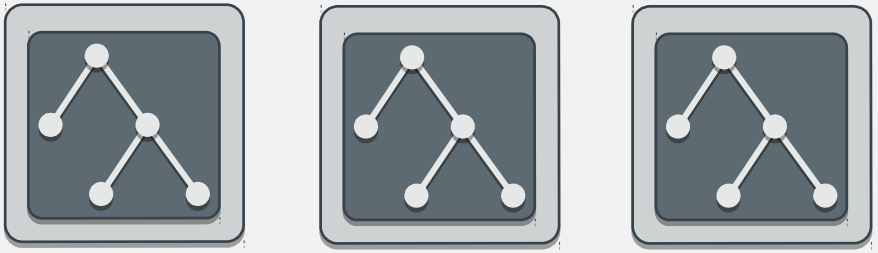
Barnaby, Flickr / CC BY 2.0


CLIENT
01
10
M
M
M


M
M
M




three metadata servers



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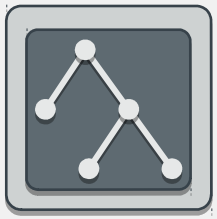
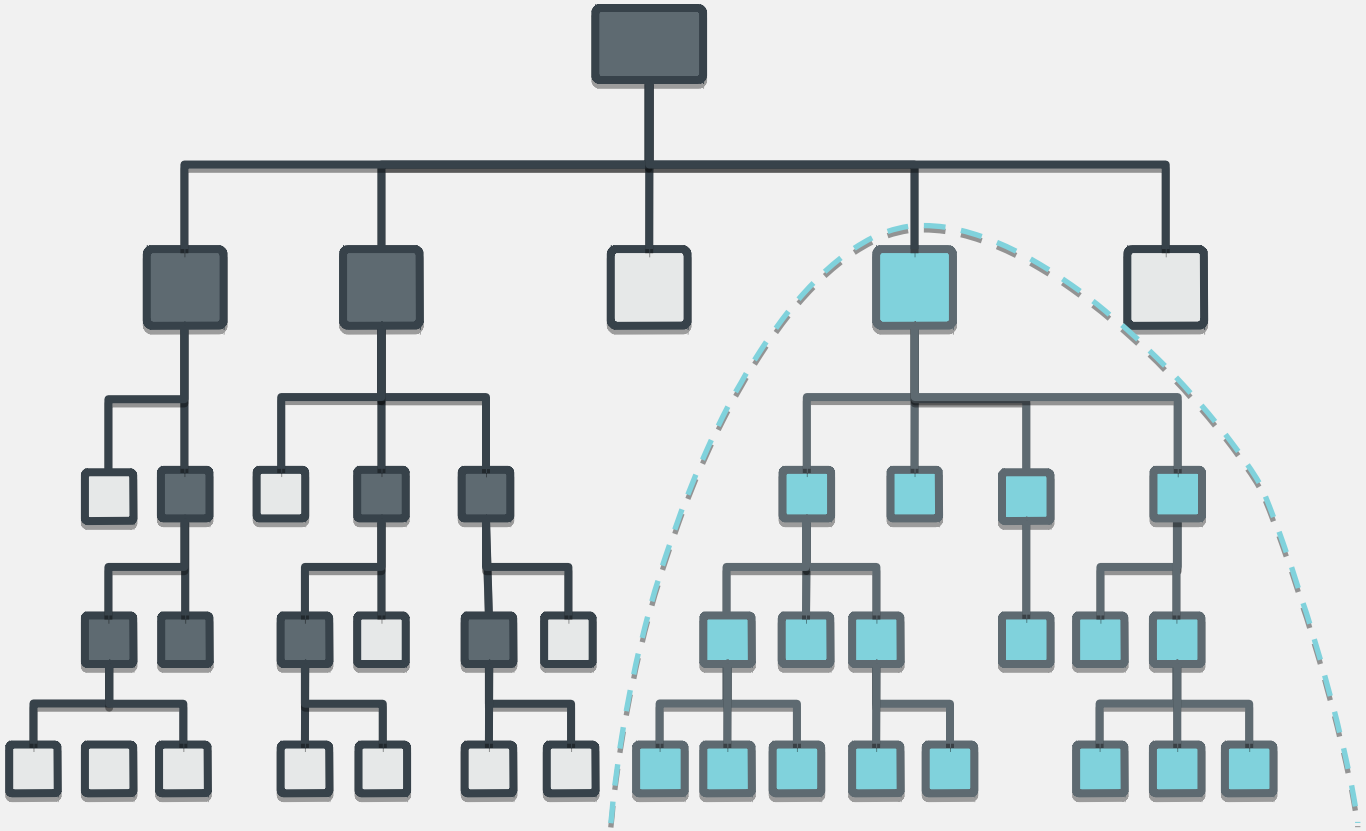
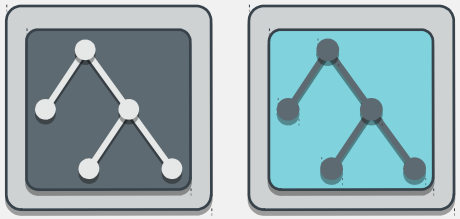
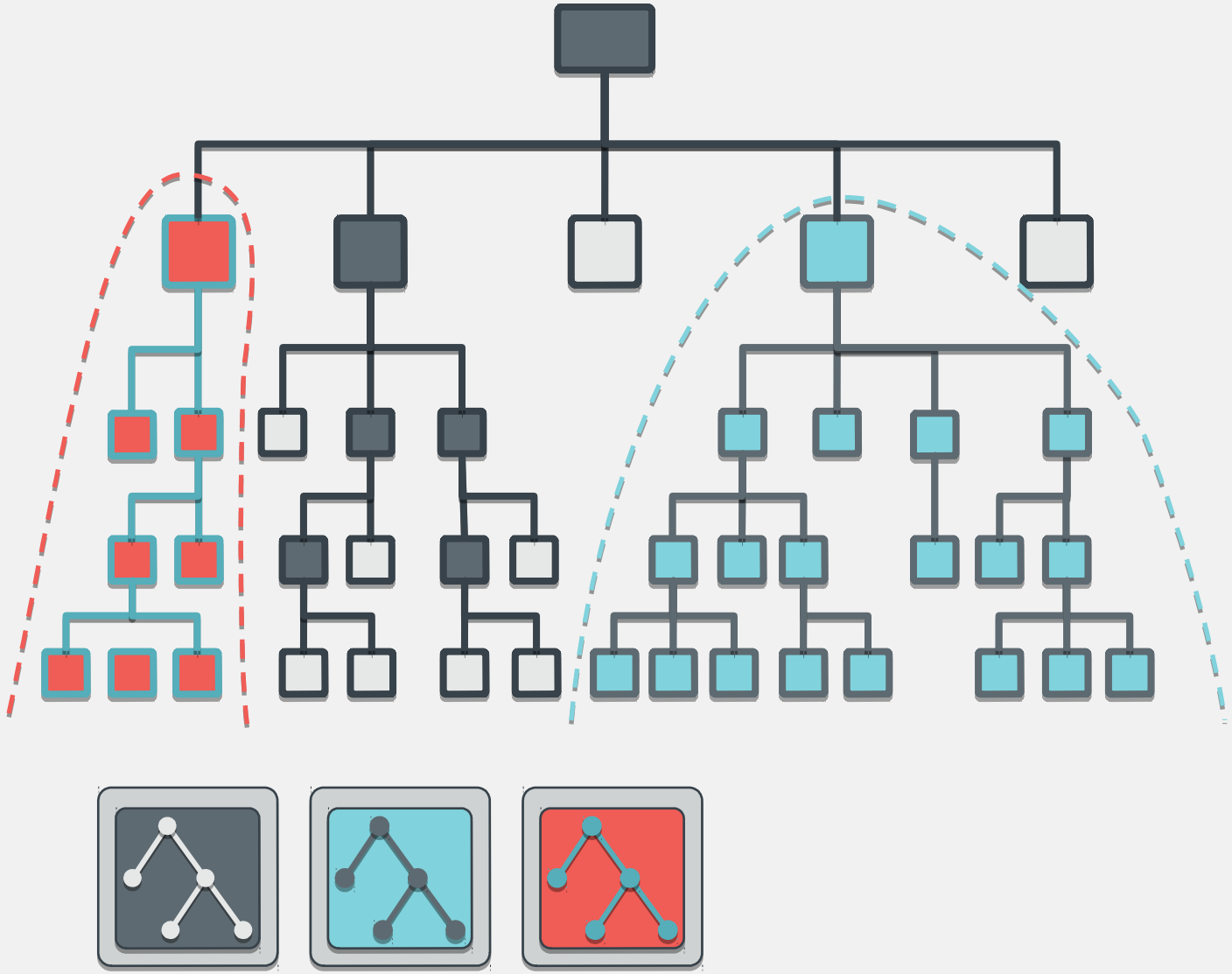
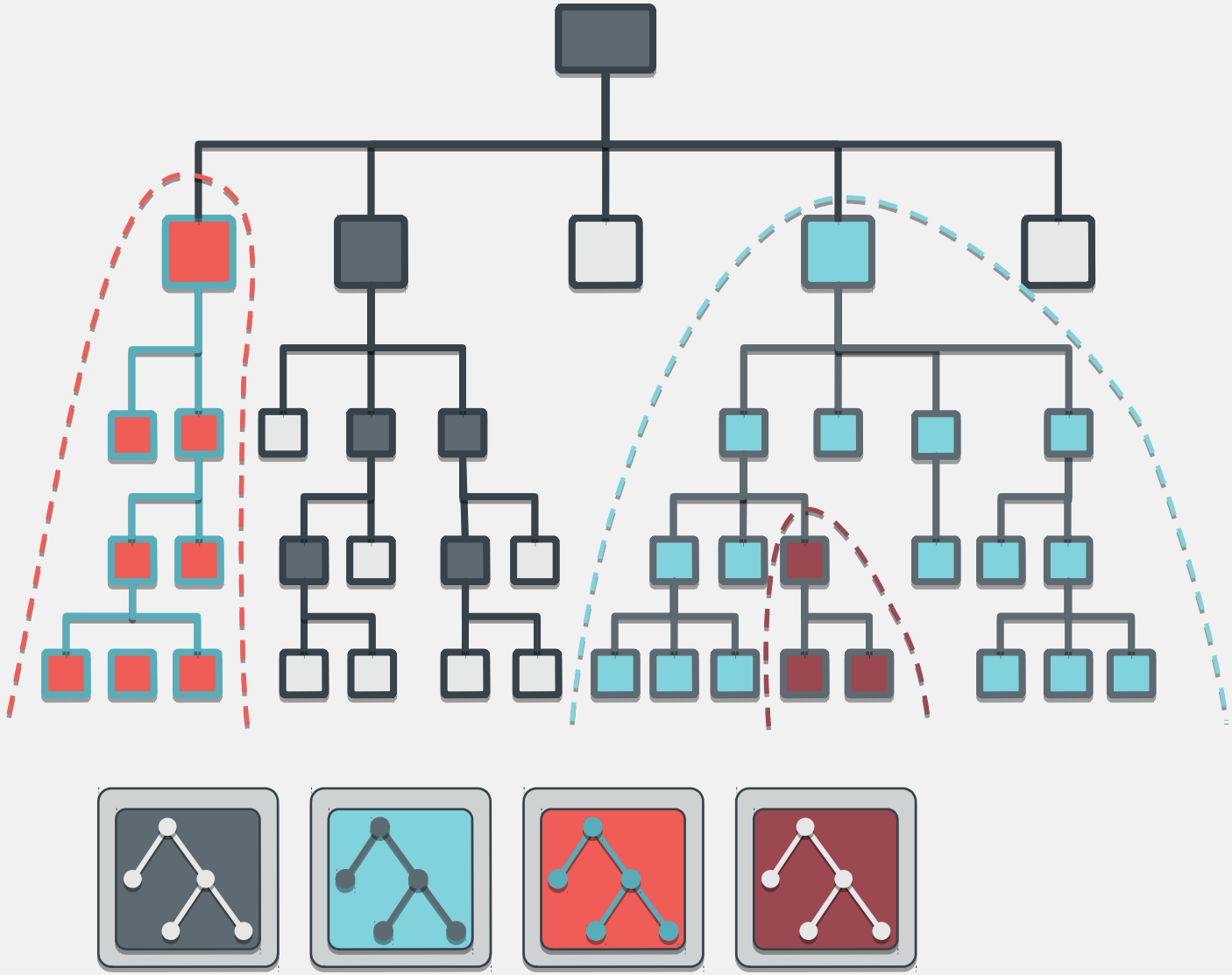
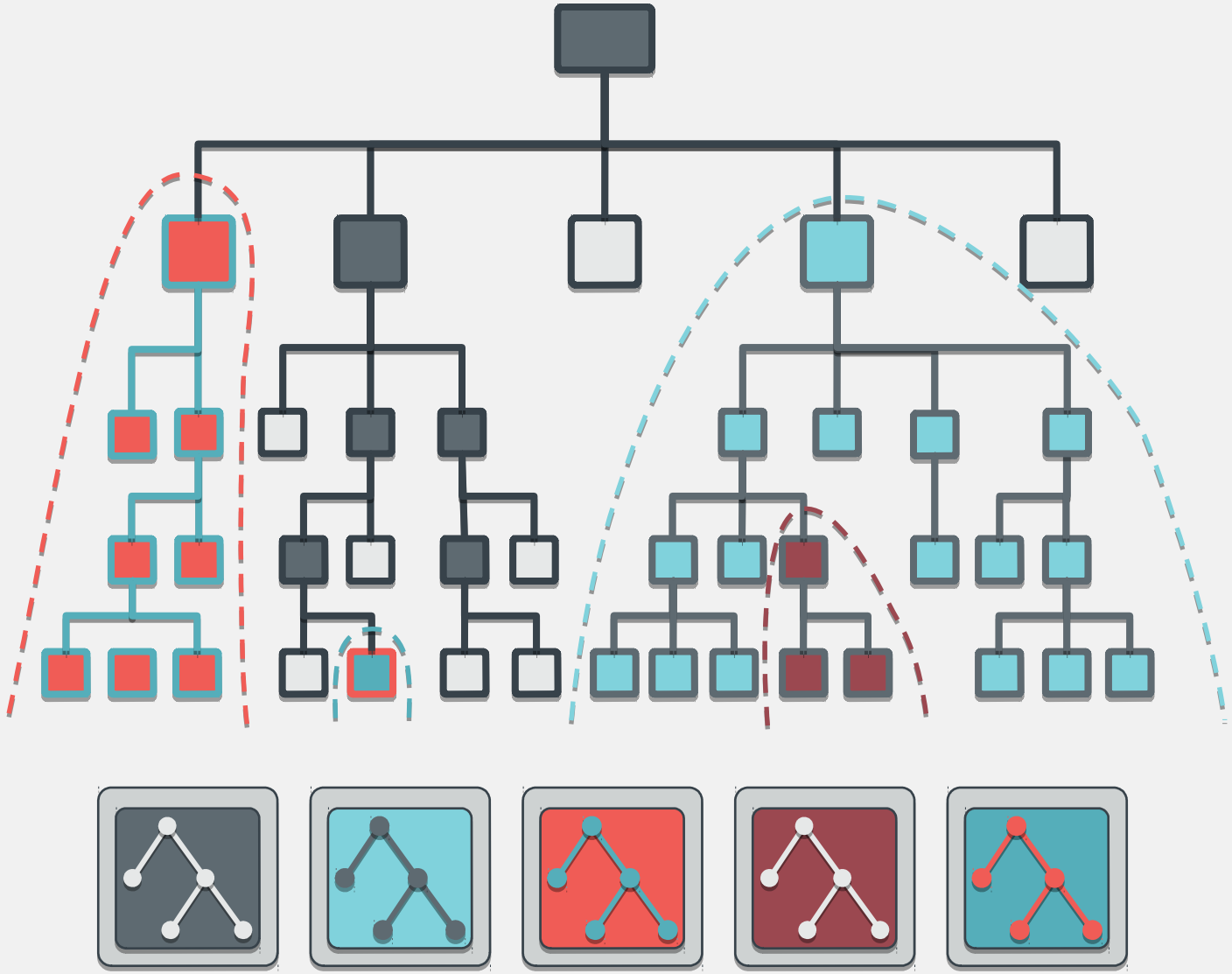












**DYNAMIC** SUBTREE PARTITIONING

# Getting Started With Ceph

Have a working cluster up quickly.

Read about the latest version of Ceph.

- The latest stuff is always at http://ceph.com/get

Deploy a test cluster using ceph-deploy.

- Read the quick-start guide at http://ceph.com/qsg

Deploy a test cluster on the AWS free-tier using Juju.

- Read the guide at http://ceph.com/juju

Read the rest of the docs!

- Find docs for the latest release at http://ceph.com/docs

# Getting Involved With Ceph

Help build the best storage system around!

Most project discussion happens on the mailing list.

- Join or view archives at http://ceph.com/list

IRC is a great place to get help (or help others!)

- Find details and historical logs at http://ceph.com/irc

The tracker manages our bugs and feature requests.

- Register and start looking around at http://ceph.com/tracker

Doc updates and suggestions are always welcome.

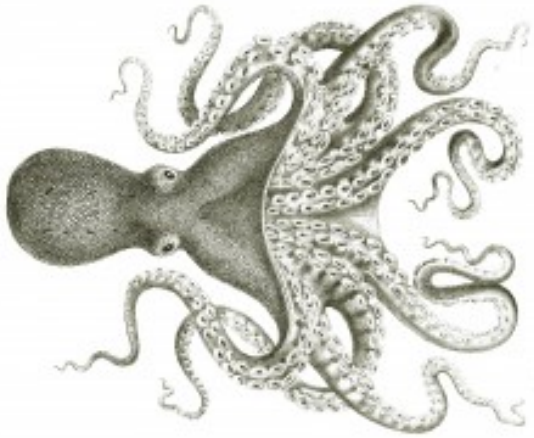
- Learn how to contribute docs at http://ceph.com/docwriting

# Ceph Hammer (v0.94.x)

Best Ceph ever.

1. Rados Performance enhancements: All Flash environments
2. Simplified RGW deployment
3. RGW *Object Versioning* and *Bucket Sharding*
4. RBD *Mandatory Locking, Object Maps, Copy on Read*
5. CephFS *Snapshot improvements*

*and many more. See https://ceph.com/releases/v0-94-hammer-released/*



HAMMER

# Questions?

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PM Director, Ceph

federico@redhat.com
@0xF2

redhat.com | ceph.com