Ceph

A file system a little bit different

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Ceph – what?

- So-called parallel distributed cluster file system
- Started as part of PhD studies at UCSC
- Public announcement in 2006 at 7th OSDI
- File system shipped with Linux kernel since 2.6.34
- Name derived from pet octopus - cephalopods

Shared file systems – short intro

- Multiple server access the same data
- Different approaches
  - Network based, e.g. NFS, CIFS
  - Clustered
    - Shared disk, e.g. CXFS, CFS, GFS(2), OCFS2
    - Distributed parallel, e.g. Lustre .. and Ceph

Ceph and storage

- Distributed file system => distributed storage
- Does not use traditional disks or RAID arrays
- Does use so-called OSD's
  - Object based Storage Devices
  - Intelligent disks

Storage – looking back

- Not very intelligent
- Simple and well documented interface, e.g. SCSI standard
- Storage management outside the disks

Storage – these days

- Storage hardware powerful => Re-define: tasks of storage hardware and attached computer
- Shift of responsibilities towards storage
  - Block allocation
  - Space management
- Storage objects instead of blocks
  - Extension of interface -> OSD standard

Object Based Storage I

- Objects of quite general nature
  - Files
  - Partitions
- ID for each storage object
- Separation of meta data operation and storing file data
- HA not covered at all
- Object based Storage Devices

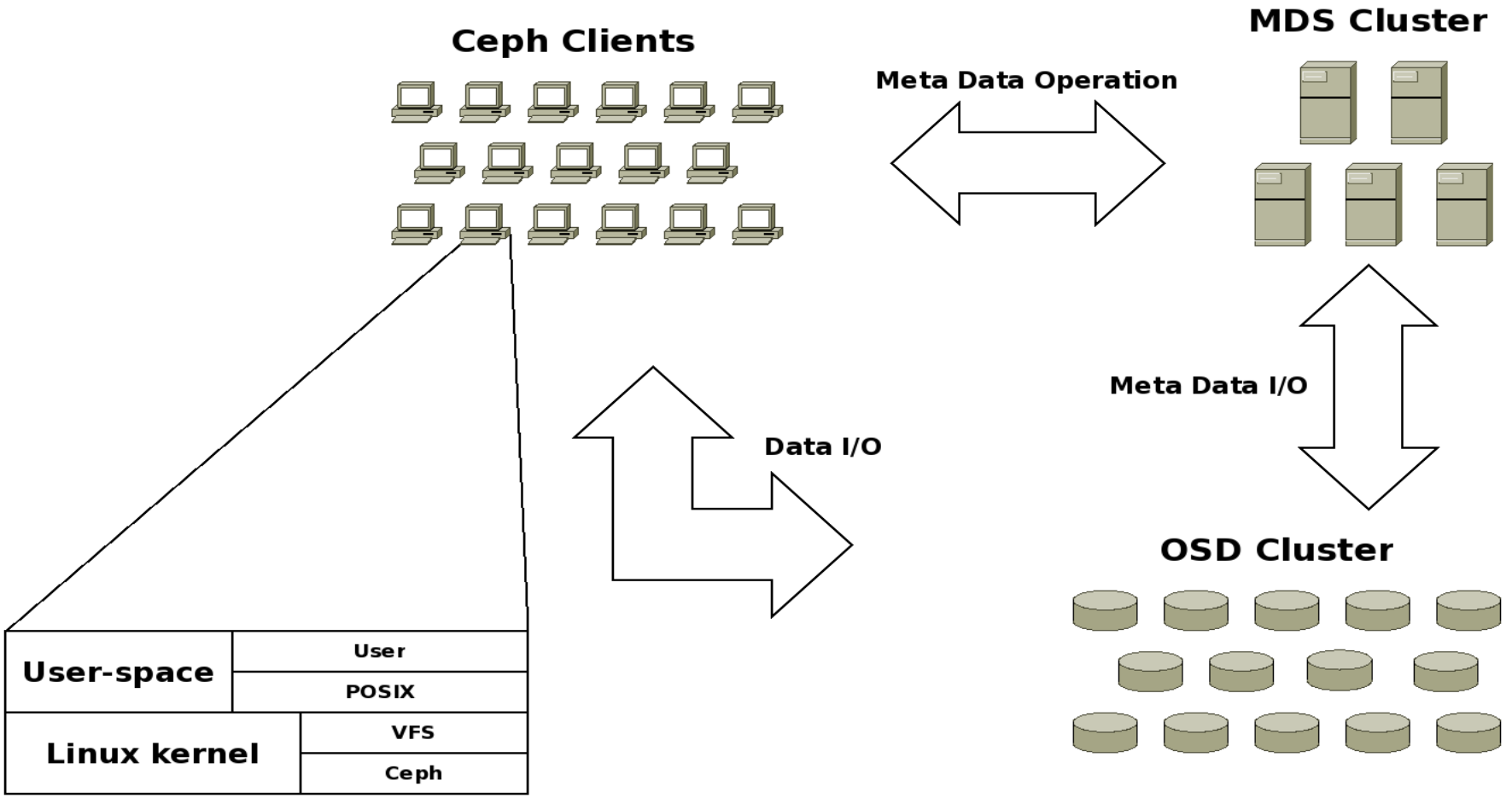
Object Based Storage II

- OSD software implementation
  - Usual an additional layer between between computer and storage
  - Presents object-based file system to the computer
  - Use a “normal” file system to store data on the storage
  - Delivered as part of Ceph
- File systems: LUSTRE, EXOFS

Ceph – the architecture I

- 4 components
  - Object based Storage Devices
    - Any computer
    - Form a cluster (redundancy and load balancing)
  - Meta Data Servers
    - Any computer
    - Form a cluster (redundancy and load balancing)
  - Cluster Monitors
    - Any computer
  - Clients ;-)

Ceph – the architecture II



Ceph client view

- The kernel part of Ceph
- Unusual kernel implementation
  - “light” code
  - Almost no intelligence
- Communication channels
  - To MDS for meta data operation
  - To OSD to access file data

Ceph and OSD

- User land implementation
- Any computer can act as OSD
- Uses BTRFS as native file system
  - Since 2009
  - Before self-developed EBOFS
  - Provides functions of OSD-2 standard
    - Copy-on-write
    - snapshots
- No redundancy on disk or even computer level

OSD failure approach

- Any OSD expected to fail
- New OSD dynamically added/integrated
- Data distributed and replicated
- Redistribution of data after change in OSD landscape

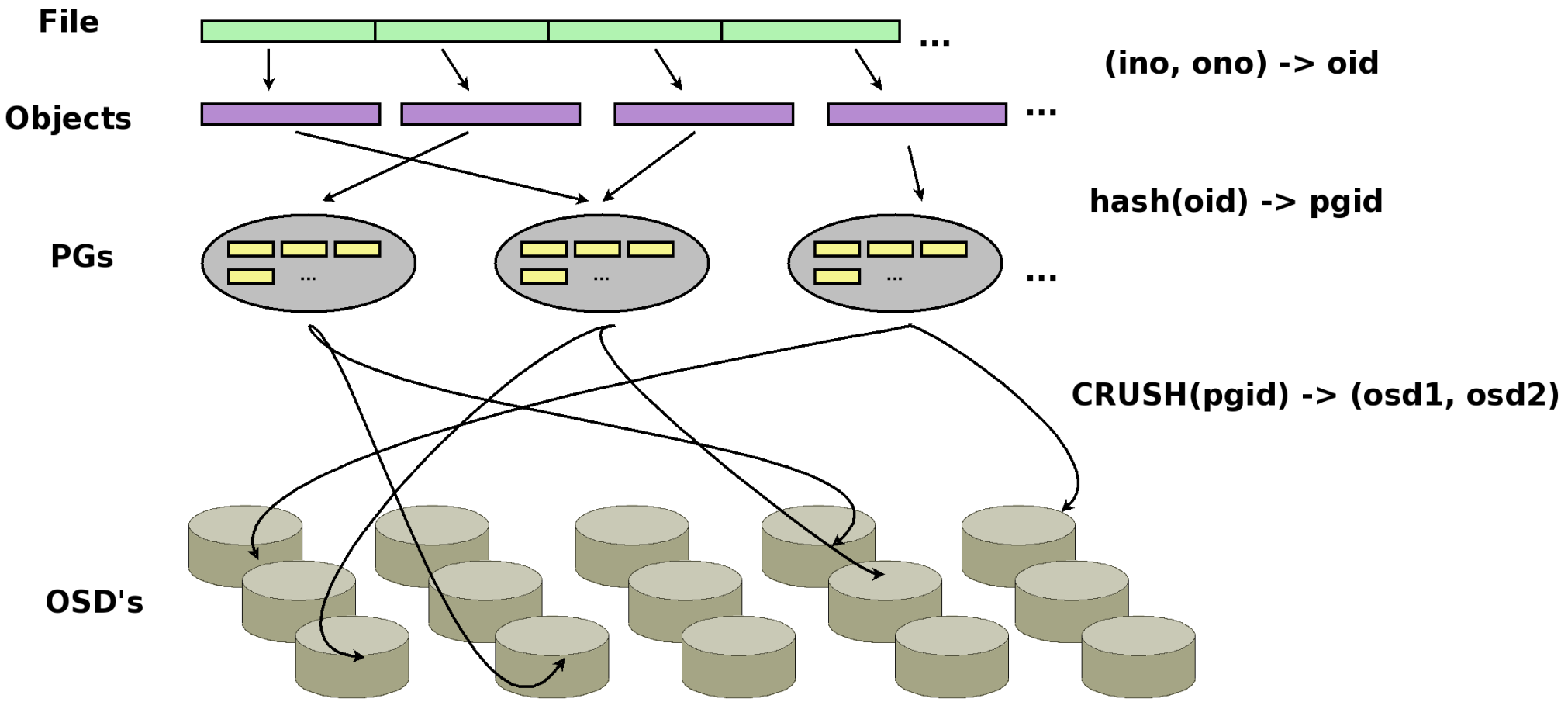
Data distribution

- File stripped
- File pieces mapped to object IDs
- Assignment of so-called placement group to object ID
  - Via hash function
  - Placement group (PG): logical container of storage objects
- Calculation of list of OSD’s out of PG
  - CRUSH algorithm

CRUSH I

- Controlled Replication Under Scalable Hashing
- Considers several information
  - Cluster setup/design
  - Actual cluster landscape/map
  - Placement rules
- Pseudo random -> quasi statistical distribution
- Cannot cope with hot spots
- Clients, MDS and OSD can calculate object location

CRUSH II


File
...
(ino, ono) -> oid
Objects
...
hash(oid) -> pgid
PGs
...
...
CRUSH(pgid) -> (osd1, osd2)
OSD's

Data replication

- N-way replication
  - N OSD's per placement group
  - OSD's in different failure domains
  - First non-failed OSD in PG -> primary
- Read and write to primary only
  - Writes forwarded by primary to replica OSD's
  - Final write commit after all writes on replica OSD
- Replication traffic within OSD network

Ceph caches

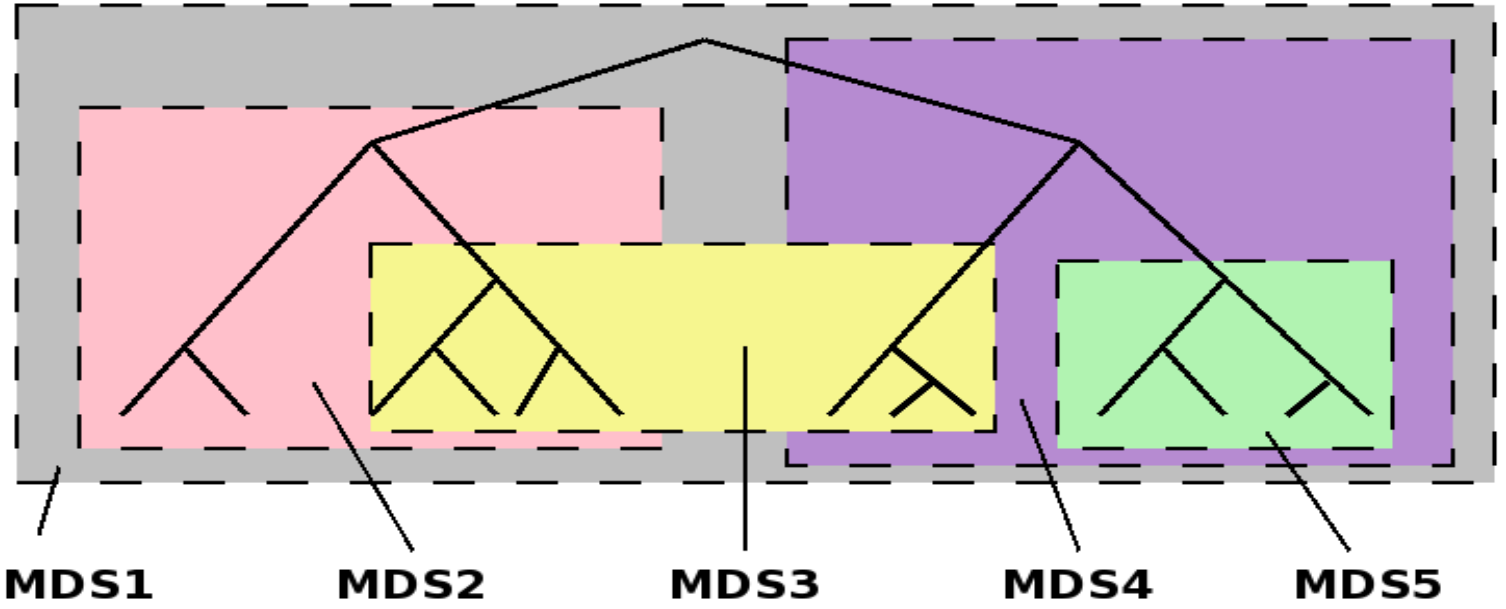
- Per design
  - OSD: Identical to access of BTRFS
  - Client: own caching
- Concurrent write access
  - Caches discarded
  - Caching disabled -> synchronous I/O
- HPC extension of POSIX I/O
  - O_LAZY

Meta Data Server

- Form a cluster
- don’t store any data
  - Data stored on OSD
  - Journaled writes with cross MDS recovery
- Change to MDS landscape
  - No data movement
  - Only management information exchange
- Partitioning of name space
  - Overlaps on purpose

Dynamic subtree partitioning

- Weighted subtrees per MDS
- “load” of MDS re-belanced



Meta data management

- Small set of meta data
  - No file allocation table
  - Object names based on inode numbers
- MDS combines operations
  - Single request for *readdir()* and *stat()*
  - *stat()* information cached

Ceph cluster monitors

- Status information of Ceph components critical
- Monitor track changes of cluster landscape
  - Update cluster map
  - Propagate information to OSD’s

Ceph cluster map I

- Objects: computers and containers
- Container: bucket for computers or containers
- Each object has ID and weight
- Maps physical conditions
  - rack location
  - fire cells

Ceph cluster map II

- Reflects data rules
  - Number of copies
  - Placement of copies
- Updated version sent to OSD's
  - OSD's distribute cluster map within OSD cluster
  - OSD re-calculates via CRUSH PG membership
    - data responsibilities
    - Order: primary or replica
  - New I/O accepted after information synch

Ceph – first steps

- A few servers
  - At least one additional disk/partition
  - Recent Linux installed
  - Ceph installed
  - Trusted ssh connections
- Ceph configuration
  - Each servers is OSD, MDS and Monitor

Summary

- Promising design/approach -> worth looking at
- High grade of parallelism -> no SPOF
- still experimental status -> not recommended for use in production
- Big installations?
  - Number of components
  - Layout

References

- http://ceph.newdream.net
- http://www.ssrc.ucsc.edu/Papers/weil-sc06.pdf

Thank you!